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The Economic Effects of Environmental Regulations on the Pollution Control Industry

Arthur D. Little, Inc, Cambridge, MA

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THE ECONOMIC EFFECTS OF ENVIRONMENTAL REGULATIONS ON THE POLLUTION CONTROL INDUSTRY

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ENVIRONMENTAL PROTECTION AGENCY

UNDER CONTRACT 68-01-4660

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The recent history (1972-1976) of the PCI has been one of better than average growth and only average profitability. Leading companies in each PCI sector enjoyed growth rates in the range of 16-22% per year (versus 9% for all U.S. manufacturing). However, the level of profitability was only about average for all U.S. manufacturing or comparable industrial segments (e.g., 10-11% after-tax return on stockholders' equity). An important exception has been the water treatment chemicals segment which has been among the most profitable in American industry.

In 1977, the markets for these pollution control products totalled $1.8 billion. These markets are projected to grow to $3.5 billion by 1983 or at a pace of 11-12% per year (in current dollars and assuming 5-7% inflation).

Current employment by the PCI in association with these markets is estimated to be 35,850 jobs. Assuming that the amount of sales generated per employee will continue to increase as well, employment is projected to grow to 43,900 in 1983.

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TABLE OF CONTENTS

	Page
List of Tables	vi
List of Figures	ix
ABSTRACT	xi
1.0 EXECUTIVE SUMMARY	1
1.1 OBJECTIVES AND METHODOLOGY	1
1.1.1 Definitions and Scope	1
1.1.2 Approach	2
1.2 INDUSTRY CHARACTERISTICS	4
1.2.1 Financial Performance	4
1.2.2 Technological Capabilities	8
1.2.3 Capacity, Supply, and Competition	9
1.2.4 Demand and Employment Estimates	11
1.2.5 Corporate Commitment and Business Risk	13
1.3 MAJOR REGULATORY EFFECTS AND ISSUES	14
1.3.1 The Municipal Bidding Process	14
1.3.2 The Role of Federal R&D	15
1.3.3 The Role of Technology Forcing Standards in Air Pollution Control Regulation	16
1.3.4 System Operation and Maintenance	17
2.0 REGULATORY IMPACTS UPON THE OVERALL PERFORMANCE OF THE POLLUTION CONTROL INDUSTRY	19
2.1 WATER POLLUTION CONTROL	19
2.1.1 The Municipal Bidding Process	19
2.1.1.1 Symptoms of the Problem	19
2.1.1.2 Some Current Procedures	20
2.1.1.3 The Bidding Process: The Center of the Problem	21
2.1.1.4 Suggested Procedures and Solutions	23
2.1.1.5 Roles and Responsibilities	24
2.1.2 The Industrial Market Sector	26

Page

2.2 AIR POLLUTION CONTROL 26

2.2.1 Standard Setting Practices 26

2.2.1.1 Frequency of Sampling 27
2.2.1.2 Technology Forcing Standards 28

2.3 RESOURCE RECOVERY 30

2.4 GENERAL ISSUES 31

2.4.1 EPA Policy Impacts 31
2.4.2 EPA/PCI Relationships 32

3.0 REGULATORY IMPACTS UPON THE PURCHASE AND OPERATION OF POLLUTION CONTROL SYSTEMS 33

3.1 THE PURCHASE DECISION 33

3.1.1 "Reluctant and Embarrassed Customers" 33
3.1.2 "Double Standards" 33
3.1.3 "Free Engineering" 34
3.1.4 Decision Factors 34
3.1.5 Regulatory Impacts 35

3.2 SYSTEM OPERATION AND MAINTENANCE 36

3.2.1 Water Pollution Control 36
3.2.2 Air Pollution Control 37

3.2.2.1 The No-Bypass Idea 37
3.2.2.2 A Possible Manpower Problem 38
3.2.2.3 The Placement of Responsibility 38

3.2.3 Resource Recovery 39

4.0 CHARACTERIZATION OF DEMAND 40

4.1 WATER POLLUTION CONTROL 40

4.1.1 The Business Environment 40
4.1.2 Municipal Specialty Equipment 45
4.1.3 Industrial Specialty Equipment 52
4.1.4 WPC Instrumentation 58
4.1.5 WPC Chemicals 61

Page

4.2 AIR POLLUTION CONTROL 66

4.2.1 The Business Environment 66
4.2.2 Specialty Equipment 67
4.2.3 APC Instrumentation 73

4.3 RESOURCE RECOVERY 74

4.3.1 The Business Environment 74

4.3.1.1 Marketing Requirements 76
4.3.1.2 Regulatory Driving Forces 76

4.3.2 Leading Technologies 77

4.3.2.1 Energy Recovery 77
4.3.2.2 Materials Recovery 78

4.3.3 Potential Markets 78

4.4 GENERAL ISSUES 82

4.4.1 Growth Potential Remains 82
4.4.2 Business Cyclicality 82
4.4.3 Some Cloudy Areas of the Crystal Ball 83
4.4.4 Employment Associated with Pollution Control Industry Demand 84

5.0 FINANCIAL PERFORMANCE OF THE POLLUTION CONTROL INDUSTRY 87

5.1 INTRODUCTION AND SUMMARY 87

5.1.1 Definitions 87
5.1.2 Financial Performance Measures 88
5.1.3 Summary of Overall Performance 89

5.2 AIR POLLUTION CONTROL EQUIPMENT 89

5.3 AIR & WATER POLLUTION CONTROL INSTRUMENTATION 93

5.4 WATER POLLUTION CONTROL EQUIPMENT 93

5.5 WATER TREATMENT CHEMICALS 96

5.6 SOLID WASTE MANAGEMENT 96

5.7 GENERAL ISSUES 99

Page

6.0 TECHNOLOGY ISSUES 101

6.1 STATUS AND NEEDS FOR TECHNOLOGY 101

6.1.1 Water Pollution Control 101
6.1.2 Air Pollution Control 102
6.1.3 Resource Recovery 103

6.2 INDUSTRY CAPABILITIES 103

6.2.1 Company Efforts 103
6.2.2 Process Oriented Approaches 105

6.3 NEEDS FOR EPA'S R&D EFFORTS 105

6.3.1 Value of EPA R&D to Date 105
6.3.2 Interest in EPA-Funded Contracts 106
6.3.3 Suggested Future Priorities 106

7.0 AVAILABILITY OF CAPACITY, SUPPLY, AND COMPETITION 107

7.1 CHARACTERIZATION OF CAPACITY 107

7.2 POTENTIAL SUPPLY CONSTRAINTS AND BOTTLENECKS 108

7.3 STATUS AND TRENDS IN COMPETITION 109

7.3.1 Air Pollution Control Equipment 109
7.3.2 Instrumentation 109
7.3.3 Water Pollution Control Equipment 109
7.3.4 Water Treatment Chemicals 110
7.3.5 Resource Recovery 110
7.3.6 Foreign Markets and Competition 110

7.4 GENERAL ISSUES 111

8.0 CORPORATE COMMITMENTS AND BUSINESS RISKS 113

8.1 CORPORATE COMMITMENTS 113

8.1.1 Water Pollution Control 113
8.1.2 Air Pollution Control 113
8.1.3 Resource Recovery 114

Page

8.2 RISK FACTORS 115

8.2.1 Water Pollution Control 115
8.2.2 Air Pollution Control 117
8.2.3 Resource Recovery 117

8.3 GENERAL ISSUES 118

APPENDIX TO CHAPTER 1 119

APPENDIX TO CHAPTER 4 129

APPENDIX TO CHAPTER 5 144

APPENDIX TO CHAPTER 7 150

LIST OF TABLES

Table No.		Page
1-1	ISSUE CATEGORIES	3
1-2	AVERAGE ANNUAL GROWTH IN SALES AND NET INCOME FOR COMPANIES IN MANOR POLLUTION CONTROL INDUSTRY SECTORS: 1972-1976	5
1-3	AVERAGE RETURNS ON EQUITY AND SALES FOR COMPANIES IN MAJOR POLLUTION CONTROL INDUSTRY SECTORS: 1972-1976	6
1-4	ESTIMATED DEMAND AND EMPLOYMENT ASSOCIATED WITH THE SUPPLY OF POLLUTION CONTROL PRODUCTS (1977 and 1983)	12
4-1	MUNICIPAL WATER POLLUTION CONTROL INVESTMENT REQUIREMENTS	46
4-2	COMPARATIVE BACKLOGS FOR SELECTED MUNICIPAL TREATMENT PROCESSES	47
4-3	MUNICIPAL WATER POLLUTION CONTROL SPECIALTY EQUIPMENT REQUIREMENTS - 1978-1990	49
4-4	1977 SHIPMENTS OF MUNICIPAL WATER POLLUTION CONTROL EQUIPMENT AND ESTIMATED GROWTH THROUGH 1983	53
4-5	WATER POLLUTION CONTROL EQUIPMENT COMPANIES	54
4-6	COMPARATIVE ESTIMATES OF REQUIRED INDUSTRIAL WASTEWATER TREATMENT INVESTMENT, 1977 CAPACITY	55
4-7	ESTIMATED BACKLOG OF INDUSTRIAL WATER POLLUTION CONTROL INVESTMENT	56
4-8	1977 SHIPMENTS OF INDUSTRIAL WATER POLLUTION CONTROL EQUIPMENT AND ESTIMATED GROWTH THROUGH 1983	57
4-9	1977 WATER POLLUTION CONTROL INSTRUMENTATION MARKETS AND GROWTH OUTLOOK THROUGH 1983	60
4-10	WATER POLLUTION CONTROL INSTRUMENTATION SUPPLIERS	62
4-11	ESTIMATED WATER AND WASTEWATER TREATMENT CHEMICAL MARKETS, 1977	64
4-12	WATER POLLUTION CONTROL SPECIALTY CHEMICAL SUPPLIERS	65
4-13	SUMMARY OF ESTIMATED AIR POLLUTION CONTROL INVESTMENT REQUIRED TO MEET EXISTING FEDERAL STANDARDS, 1977-1986	68

LIST OF TABLES (cont.)

Table No.		Page
4-14	ESTIMATED 1977 AIR POLLUTION CONTROL EQUIPMENT SHIPMENTS AND ASSOCIATED INSTALLATION AND GROWTH THROUGH 1983	70
4-15	PARTICULATE CONTROL SYSTEM SUPPLIERS	71
4-16	SO_x CONTROL SYSTEM SUPPLIERS	72
4-17	AIR POLLUTION CONTROL INSTRUMENTATION SUPPLIERS	75
4-18	RESOURCE RECOVERY ACTIVITIES IN THE UNITED STATES	80
4-19	MARKETS FOR RESOURCE RECOVERY FACILITIES	81
4-20	ESTIMATED NUMBER OF JOBS ASSOCIATED WITH THE SUPPLY OF POLLUTION CONTROL PRODUCTS	85
5-1(A)	AVERAGE ANNUAL GROWTH IN SALES AND NET INCOME AND AVERAGE DEBT RATIOS FOR POLLUTION CONTROL INDUSTRY GROUPS AND COMPARATIVE INDUSTRY COMPOSITES	90
5-1(B)	AVERAGE ROE AND ROS FOR 1976 AND FOR THE PERIOD 1972-1976 FOR PCI GROUPS AND COMPARATIVE INDUSTRY COMPOSITES	91
5-2	AIR POLLUTION CONTROL EQUIPMENT MANUFACTURERS	92
5-3	AIR AND WATER POLLUTION CONTROL INSTRUMENTATION SUPPLIERS	94
5-4	WATER POLLUTION CONTROL EQUIPMENT MANUFACTURERS	95
5-5	WATER TREATMENT CHEMICAL MANUFACTURERS	97
5-6	SOLID WASTE MANAGEMENT SYSTEMS SUPPLIERS	98
A4.1	ESTIMATED SPECIALTY EQUIPMENT BACKLOG REQUIRED BY MUNICIPALITIES, BY SIZE OF PLANT	129
A4.2	ESTIMATED SPECIALTY EQUIPMENT BACKLOG REQUIRED BY MUNICIPALITIES, BY TYPE OF FACILITY	130
A4.3	COMPARATIVE ESTIMATES OF INDUSTRIAL WASTEWATER TREATMENT BACKLOG, BY INDUSTRY, 1977 CAPACITY	131

LIST OF TABLES (concl.)

Table No.		Page
A4.4	LEADING INDUSTRIAL CATEGORIES IN VIOLATION OF THE JULY 1, 1977 (BPT) STATUTORY	133
A4.5	ESTIMATED ANNUAL EXPENDITURES FOR INDUSTRIAL WASTEWATER TREATMENT FACILITIES, 1974-1978	134
A4.6	ESTIMATED APC INVESTMENT REQUIRED TO MEET EXISTING FEDERAL STANDARDS, 1977-1986	135
A4.7	SUMMARY OF ESTIMATED APC INVESTMENT REQUIRED TO MEET EXISTING FEDERAL STANDARDS, 1977-1986	138
A4.8	CONTROL TECHNOLOGIES USED IN EPA-FUNDED ECONOMIC IMPACT STUDIES	139
A5.1	AIR POLLUTION CONTROL EQUIPMENT MANUFACTURERS	144
A5.2	AIR AND WATER POLLUTION CONTROL INSTRUMENTATION MANUFACTURERS	145
A5.3	WATER POLLUTION CONTROL EQUIPMENT MANUFACTURERS	146
A5.4	WATER TREATMENT CHEMICAL MANUFACTURERS	147
A5.5	SOLID WASTE MANAGEMENT COMPANIES	148
A5.6	INDUSTRY COMPOSITES FOR FINANCIAL COMPARISONS	149
A7.1	MAJOR PARTICIPANTS IN THE POLLUTION CONTROL INDUSTRY	150

LIST OF FIGURES

Figure No. Page

4.1 MUNICIPAL AND INDUSTRIAL MARKETING INTERFACES 41

4.2 HISTORICAL LEVELS OF FEDERAL GRANTS FOR MUNICIPAL TREATMENT PLANTS 43

4.3 COMPARATIVE DISTRIBUTION OF MUNICIPAL WPC EQUIPMENT VALUE BY SIZE OF PLANT 50

4.4 PROFILE OF MUNICIPAL WPC EQUIPMENT INSTALLATIONS, 1990 51

ABSTRACT

THE ECONOMIC EFFECTS OF ENVIRONMENTAL REGULATIONS ON THE POLLUTION CONTROL INDUSTRY

by Arthur D. Little, Inc., (August 1978 - Cambridge, Massachusetts)
for the U. S. Environmental Protection Agency (Contract No. 68-01-4660)
(Report No. EPA/230/1-78-002)

The objectives of this study included: identifying constraints on the ability of the pollution control industry (PCI) to support future regulatory needs; evaluating the performance of participating companies; estimating markets and associated employment; and updating an earlier (1972) analysis. The analysis is both descriptive and diagnostic, addressing the impact of the regulatory process upon the industry and, conversely, the impact of the industry upon the regulatory process.

The business segments covered in the study are: the equipment and instrumentation systems used in the control of air pollution from stationary sources; the equipment, instrumentation, and chemicals associated with water pollution control; and the systems being developed to recover energy and materials from municipal solid waste.

The recent history (1972-1976) of the PCI has been one of better than average growth and only average profitability. Leading companies in each PCI sector enjoyed growth rates in the range of 16-22% per year (versus 9% for all U. S. manufacturing). However, the level of profitability was only about average for all U. S. manufacturing or comparable industrial segments (e.g., 10-11% after-tax return on stockholders' equity). An important exception has been the water treatment chemicals segment which has been among the most profitable in American industry.

The larger of the leading PCI companies typically have annual sales of $200-$700 million and are not among the multi-billion dollar firms which command the greater financial resources within the U. S. manufacturing industry. Hence, the PCI has been limited by the resources of its leading participants as well as by disappointing profitability.

In 1977, the markets for these pollution control products totalled $1.8 billion. These markets are projected to grow to $3.5 billion by 1983 or at a pace of 11-12% per year (in current dollars and assuming 5-7% inflation). Faster growing segments include those of flue gas desulfurization systems and resource recovery systems.

Current employment by the PCI in association with these markets is estimated to be 35,850 jobs. Assuming that the amount of sales generated per employee will continue to increase as well, employment is projected to grow to 43,900 in 1983. These employment benefits to the economy do not include pollution control jobs provided by consulting engineering firms, fabricators, and construction contractors.

A diagnostic examination of the impact of the regulatory process upon the industry focuses on four major issues of concern to the PCI and of importance to future regulation: the municipal bidding process; the role of Federal R&D; the effects of technology forcing standards; and the operability and maintenance of control systems.

The municipal bidding process is the issue believed to be having the greatest impact upon the PCI. This is the process by which Federal construction grant monies are expended for specialized sewage treatment equipment and instrumentation systems. Problems recommended for further examination within the municipal bidding process include bid-shopping practices, implications for plant operation, and responsibilities for system performance.

Federal support of R&D may be more critical to U. S. technological leadership in pollution control than in other regulatory program areas. Manufacturing industries seeking to solve their own pollution control problems do not have the right motivation for developing new technology. The pollution control industry has neither the corporate resources, the historical capability, or the profitability needed to pursue basic research.

The effects of technology forcing standards are raised with regard to the possible setting of new particulate emission targets for utility boilers. The point of concern developed here is that particulate control has been the mainstay both of the air pollution control business and of the regulation of national air pollution levels. The possible placement of new standards at the frontier of technological capability may introduce problems of overextended guarantees, system failures, lack of user confidence, and unsatisfactory performance.

The operation and maintenance of pollution control systems is of growing concern to environmental regulators. The major focus of enforcement, to date, has been placed upon the installation of systems directed at achieving the installation of control systems may work against maintaining the desired operation and performance of those systems. The municipal bidding process and technology forcing particulate control standards are cited as possible illustrations of this problem.

1.0 EXECUTIVE SUMMARY

1.1 OBJECTIVES AND METHODOLOGY

In its Contract (68-01-4660) with Arthur D. Little, Inc. (ADL), the U. S. Environmental Protection Agency (EPA) asked for a diagnostic analysis of the pollution control industry (PCI). The objectives of the study were to aid EPA decision-making by:

- identifying constraints on the ability of the PCI to meet the needs and market demands deriving from EPA's regulatory initiatives;
- evaluating the performance of PCI member companies and their derivative attitudes towards future investments;
- estimating markets and associated employment associated with the PCI and its role in serving environmental regulatory requirements; and
- updating an earlier (1972) economic impact analysis of this industry.*

Two kinds of impacts were addressed in this study: (1) the impact of the regulatory process upon this industry and, conversely, (2) the impact of this industry upon the regulatory process.

1.1.1 Definitions and Scope

The primary focus of this study was placed upon the companies which supply specialized equipment, systems, and products for use in pollution control applications. Companies which participate in activities related to these systems and products were not a part of our analysis, e.g., construction firms, consulting engineers, fabricators, etc.

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*"Economic Impact Study of the Pollution Abatement Equipment Industry," Report to EPA by Arthur D. Little, Inc., December 1972 (EPA Contract No. 68-01-0553).

The major sectors of the PCI covered by this study include:

1) Air Pollution Control (APC)

   Our analysis covered the equipment and instrumentation associated with the control of particulate and gaseous emissions from stationary sources. It did not cover products associated with the control of emissions from mobile sources.

2) Water Pollution Control (WPC)

   Attention was given to three kinds of WPC products: specialty equipment, instrumentation, and specialty chemicals.

3) Resource Recovery

   The study was limited to the emerging business for systems designed to recover energy and materials from municipal solid waste (MSW). It did not include the businesses associated with the collection transportation, and landfilling functions in solid waste management (SWM).

The time horizon of our analysis extended through the 1980's. Markets were reported in 1977 dollars. Geographically, the study was limited to the domestic industry and its domestic markets. Foreign opportunities and competition were considered to the extent that they are important in characterizing U. S. companies and the domestic marketplace. Generally speaking, pollution control businesses do not have important differences among major U. S. regions; therefore, a region-by-region analysis was not part of this work.

1.1.2 Approach

As we began work, EPA priorities for this updated analysis of the PCI began to change from that of the 1972 study.* The major change was one of focus and emphasis. In addition to developing a descriptive study of the PCI, we were directed to provide a more diagnostic study of the problems facing this industry. We were asked to identify critical issues, the ways in which EPA policies appear to affect them, and to recommend potentially fruitful ways in which EPA's policies might better sustain a healthier pollution control industry while still fulfilling EPA's statutory responsibilities.

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*Supra.

Our major resource for doing this study was a series of interviews with representative pollution control companies. With the change in focus and emphasis, however, we postponed our industry interviews until we had gained a better understanding of some of the issues of interest to EPA and the PCI. We developed this preliminary understanding through discussions with EPA, other Federal agencies, and industry associations. We talked to about 20 EPA staff members from at least seven different areas of activity. We met with representatives from the Department of Commerce, the Council of Environmental Quality, and the Department of Energy. We also solicited issues related to our study from representatives of the Environmental Industry Council (EIC), the Industrial Gas Cleaning Institute (IGCI), the Water and Wastewater Equipment Manufacturers Association (WWEMA), and the Water Pollution Control Federation (WPCF). On the basis of those discussions, we developed nine issue categories. These categories are listed in Table 1-1, below. Specific points for discussion which we used within each of these categories may be found in Appendix 1.

Table 1-1

ISSUE CATEGORIES

1. Regulatory Impacts upon the:
    - A) Operation and Performance of the PCI
    - B) Customer Purchase and Operation of Pollution Control Systems
    - C) Costs and Benefits of Pollution Control Compliance
2. Industry Capabilities for:
    - A) Meeting the Changing Bases of Demand
    - B) Developing Needed Technologies
    - C) Providing Sufficient Production Capacity
    - D) Achieving Attractive Financial Returns
    - E) Sustaining Sufficient Competition
3. Company-Specific Capabilities and Attitudes for:
    - A) Continued Investment in the Pollution Control Business

Our interviews with pollution control companies extended over a period of four months from November 1977 through February 1978. These interviews were handled by a team of six ADL staff members. We visited more than 30 companies from which roughly 80 people gave of their time and effort. Several of these companies participate in more than one PCI sector. Hence, 15 of these companies were resources to us on the APC equipment business and 17 were resources on WPC equipment. APC equipment and WPC equipment received the greatest emphasis as the "heart" of their respective business sectors. We also contacted four suppliers of WPC chemicals and another four suppliers of air and/or water instrumentation systems. We also talked with eight companies participating in the resource recovery business.

We were not able to extend our coverage to other industries having relevant inputs to many of the issues in this study. For that reason, the issues and recommendations in this study may be parochial to our major source of information in this study: the manufacturers of specialized pollution control products.

1.2 INDUSTRY CHARACTERISTICS

1.2.1 Financial Performance

A typical leading supplier of pollution control products participates in several other businesses. Very few of the larger firms can associate more than 50% of their annual sales volume to environmentally related businesses. As a result, our financial analyses of representative pollution control activities are largely limited to financial statistics on entire corporate activities. This has the danger of misrepresenting the financial returns of pollution control businesses, but it has been our experience that overall corporate returns for the leaders of the PCI are fairly good indicators of their returns in their component pollution control businesses.

Representative growth rates and profitabilities for companies in five major sectors of the PCI are summarized in Tables 1-2 and 1-3 covering the the period 1972-1976. Comparable statistics are provided for ALL U. S. MANUFACTURING and larger industry segments reasoned to be comparable to the individual PCI sectors. The historical growth rates and profitabilities in Tables 1-2 and 1-3 were developed from composite performance data for groups of companies participating in each of the sectors. The companies used for this analysis are listed in Appendix 5. The companies used for the analysis were those believed to have 10% or more of their total corporate sales in environmentally related businesses. The instrumentation companies generally reflect an even smaller participation in this business area.

TABLE 1-2

AVERAGE ANNUAL GROWTH IN SALES AND NET INCOME FOR COMPANIES IN MAJOR POLLUTION CONTROL INDUSTRY SECTORS: 1972-1976

PCI Sectors:	Average Sales Growth 1972-1976 (%/yr)	Average After-Tax Income Growth 1972-1976 (%/yr)
APC/WPC Instrument	16	25
APC Equipment	20	23
WPC Equipment	18	19
Resource Recovery Systems	18	13
Water Treatment Controls	22	20
Comparative Industry Composites:		
All Manufacturing	9	15
Industrial Machinery	18	11
Industrial Chemicals	17	18
Instrumentation	16	25

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poors' Industry Survey.

TABLE 1-3

AVERAGE RETURNS ON EQUITY AND SALES FOR COMPANIES IN MAJOR POLLUTION CONTROL INDUSTRY SECTORS: 1972-1976

PCI Sectors:	Average ROE 1972-1976 (%)	Average ROS 1972-1976 (%)
APC/WPC Instrument	11	5
APC Equipment	10	4
WPC Equipment	11	4
Resource Recovery Systems	11	5
Water Treatment Controls	15	7
Comparative Inudstry Composites:		
All Manufacturing	13	5
Industrial Machinery	14	6
Industrial Chemicals	14	7
Instrumentation	10	4

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poors' Industry Survey.

The average annual growth in sales (calculated in current dollars) for the PCI sectors was clearly stronger than the 9% per year growth for ALL MANUFACTURING. The range of growth for the equipment systems sectors (APC, WPC, Instrumentation, and Resource Recovery) was similar to that for the comparative industrial machinery industry composite, or between 16-20% per year. The WPC chemicals business enjoyed a greater growth (22% per year) than that for industrial chemicals generally (17% per year).

In terms of the growth in profits, all sectors did as well, if not better, than their industry composites. On an annual basis, this growth in profit ranged from 18-25% per year across these company groups.

The average return on stockholders' equity (Table 1-3) for these companies in the years 1972-1976 ranged from 10-11% for the equipment and instrumentation sectors to 15% for WPC chemicals. This compares to a range of 10-14% for the instrumentation, industrial machinery, and ALL MANUFACTURING categories and to 14% for the industrial chemical composite. Hence, on this return-on-investment measure, the PCI companies have been performing at only an average level of profitability for American industry; some have not even performed at that level. The same is true in terms of their average after-tax return on sales.

In summary, the PCI has generally enjoyed greater than average growth with only average profitability. An important exception to this is the WPC chemicals sector--really a water treatment chemicals sector--which has been among the most profitable in American industry. This kind of "profitless prosperity" mirrors the disappointment which many PCI companies have found in this "glamor industry." Growth markets usually provide higher than average profitabilities which in turn stimulate needed business investments. This history of average or lower than average profitability is working against investment in new plants and technologies by companies within the PCI.

A final and important characteristic of leading pollution control companies is that they typically do not have the financial strength of multi-billion dollar corporations. The largest PCI participants typically are intermediate in size, e.g., with corporate sales of from $200 to $700 million per year. EPA's dependence upon this industry to solve future pollution control problems is thereby more tenuous than other Federal regulatory efforts which depend upon industries comprised of multi-billion dollar corporations. The PCI is not only hampered by profitabilities which discourage further investment, but also by limited corporate resources to manage the risks associated with this enforcement-driven market.

1.2.2 Technological Capabilities

The availability of needed technology corresponds to the maturity of the major market segments within the PCI, i.e., there's a greater need for technological development in resource recovery at the present time than there is in air and water pollution control.

Needed technology for near-term water pollution control problems is believed by the PCI to be well-developed. An issue now is just how much tertiary or other advanced treatment is actually going to be required in the 1980's. One of the stimuli for new WPC product innovation in recent years has been the need for energy conserving technologies. Insofar as it takes three to five years to develop a new control technology, future pollutant-specific regulations (i.e., for toxics and hazardous materials) will probably be met through available technology.

It is reported that the rate of truly new product innovation in water pollution control has declined--as evidenced, for example, in industry tradeshows. Some of the motivation for developing new products has also changed. The traditional market of greatest focus for leading wastewater treatment equipment suppliers--the municipal market--has become less profitable. In earlier years, WPC equipment manufacturers would develop new products for the municipal market and then look for further applications in the industrial market. Now a reverse priority is in effect--there being indications that lesser grades of traditional equipment are being manufactured to meet the needs of a "low-price, bid-shopping" municipal business.

Air pollution control technologies are employed for either particulate or gaseous emission control. For some time, the PCI has believed that adequate particulate control technology exists to meet regulatory needs. A renewed emphasis by EPA on higher percentage removals of particulates has introduced a new phase of competitive activity in the utility segment of the particulate market. Hence, although technology has been available for the control of particulates, there have been recurrent opportunities for better performance from the established technologies.

Gaseous emission control remains a major frontier for new technological development. The proving of technologies for the control of SO_2 emissions has been going on for at least a decade. Controlling NO_x, hydrocarbons, carbon monoxide, and hazardous emissions still lies ahead. In the area of gaseous emission control, air pollution control progress can be viewed as having been partly technology constrained.

The proving of technology is very much a part of current resource recovery efforts in the municipal solid waste marketplace. Waterwall incineration has been proven abroad, but still must be considered to be in its early stages of commercialization in this country. Technologies directed at producing refuse derived fuels hold equal promise but are still to be proven. Recent domestic experience with pyrolysis systems has been disappointing, and the timetable for their commercial application has been set back accordingly.

The technological capabilities of the PCI vary from sector to sector and from company to company. Current capabilities may be related to at least two factors: the historical importance of R&D for these companies and the recent profitabilities of these businesses. Environmental regulation has created growth markets for what had been mature businesses for most of these leading companies. The mature businesses in these companies had not required R&D, and R&D budgets had been historically on the low side. The first waves of environmental regulation have been directed at "catching up" with pollution control problems with already available technologies. Hence, these early legislated markets have not really required great R&D capabilities either. In fact, this has proven to be a point of frustration to those who have developed modern technologies in advance of actual market need.

If these companies are to change their emphasis on technological development, potential profitability would need to be sufficiently attractive to encourage that investment. However, the PCI is not currently in a good position to be a strong resource for developing new technologies--R&D has not been an important part of its history and the recent average profitability of this business does not encourage a change in that pattern.

Increased emphasis upon in-process approaches to pollution control presents a further challenge to the PCI. It is difficult to document (and it will continue to be so) how much of this is being done. As it gains importance, it is not clear to what extent the traditional PCI companies will share in the new opportunity. Those PCI companies which now participate in process equipment or combustion technology are in a better position to benefit from this transition. The problem is that these approaches may tend to be handled by internal customer engineering staffs or process engineering firms, and that the markets for in-process approaches will not be identifiable as environmentally-driven demand.

1.2.3 Capacity, Supply, and Competition

Normally, these three subjects would deserve separate sections in a microeconomic impact study of an industry. In this study, we have attempted to place more emphasis upon diagnosing problems and constraints than upon providing an evenly distributed descriptive study of the PCI.

There are simply no apparent major constraints (i.e., shortages) in the PCI at this time with regard to either capacity, supply, or competition. In terms of capacity and competition, current problems are not ones of "too little" but more those of "too much." Shortages of material and other bottlenecks are constraints which are largely beyond the control of this industry and which can appear at any time. Except for some items which have seemed to have always had long delivery times (e.g., specialty pumps), no serious shortages are being experienced now or envisioned for the near future.

Any potential problems in manufacturing capacity in the near future are buffered by the extended use of outside fabricators by the equipment companies. There is no concern about the near-term availability of good fabricating shops. The greater limitation upon capacity in periods of peak demand is believed to more likely come from a shortage of skilled manpower than from one of manufacturing capability.

Between 500 and 1,000 firms participate in the major sectors of the PCI covered by this report. In mature businesses such as air and water pollution control equipment markets, the top 15-30 firms account for 60-80% of the total business.

The problem of "too much" competition has been most evident in the markets for new technologies. Markets for flue gas desulfurization systems and resource recovery systems are outstanding examples in which more than a sufficient number of competitors have appeared to supply available markets. There can be no question that competition has been working in these frontier markets. It has been working so well that most of the companies have yet to make any profits in these markets.

While foreign technology appears to be playing an increasing role in the U. S. market, foreign companies have not been notably successful in achieving U. S. market positions. The greatest influence of foreign competition has come through licensing relationships with U. S. manufacturers. More significant inroads have been made by foreign companies in pollution control instrumentation, but that is more characteristic of international competition in instrumentation than it is of the pollution control business. Even there, the proportion of the domestic market held by foreign suppliers is probably 10% or less.

The dominant source of competitive advantage in pollution control markets tends to be marketing position. Defined to include marketing capability, customer know-how, and business experience, it is market position which has provided the basis for growth by PCI companies and protected them from attempts by multi-billion dollar companies to enter these markets.

After a decade of "growth and glamor" attributed to PCI businesses, not a single billion-dollar corporation has entered a major sector of this business and successfully carved out a broad leadership position in it. This has been most notably illustrated in the water treatment specialty chemical business where the profits have been sufficiently attractive to draw the attention of even the most profitable segments of American industry. There, the leading suppliers are the same as those who led the industry five and ten years ago, and their market shares have not suffered.

Many participants in PCI businesses foresee a significant shakeout of competition--because of low profitability and the overabundance of competitors. With that is anticipated an improvement in profitability and stability. We cannot agree with that projection because of the continued strong interest by potential new entrants in its markets. We expect as many companies to enter these businesses over the next decade as drop out of them. In short, we foresee that turnover--not shakeout--will characterize this market over the near-term; but that turnover may be significant.

1.2.4 Demand and Employment Estimates

The estimated demand and associated employment for the major sectors of the PCI covered in this study are summarized in Table 1-4. The markets for specialty equipment and products in 1977 totaled roughly $1.8 billion and are projected to grow to a level of $3.5 billion by 1983.

WPC equipment markets in 1977 represented the sum of about $290 million from municipal sewage treatment and about $260 million from industrial wastewater treatment. This represents a reversal from the breakdown in recent years when the industrial market had been the larger of the two. With the passing of the 1977 deadline for industrial treatment compliance, the industrial market has quieted down while the Federal funding program has sustained the municipal market. Over the next five to ten years, the municipal market is expected to grow at a pace of 10-12% per year and in the industrial market is expected to grow at a pace of 8-10% per year.

The WPC instrumentation market is estimated to have been about $150 million in 1977 including both its municipal and industrial segments. Growth rates over the next five to ten years are expected to be similar to those for WPC specialty equipment. APC instrumentation is somewhat less than a $50 million market and is expected to grow at a 6-8% annual growth rate into the late 1980's.

The markets for WPC chemicals (both bulk and specialty) were around $250 million in 1977. An associated market of $650 million is enjoyed by many of the same companies in water treatment applications. The growth rate for wastewater treatment chemicals is forecasted at 15-19% per year out of a total business for water and wastewater treatment chemicals which is expected to grow at 12% per year.

The APC equipment business in 1977 is estimated at $700 million annually. About 10% of that was associated with the control of gaseous emissions, primarily SO_2. The remainder represents business associated with the control of particulates--the traditional market for air pollution control suppliers. These market estimates represent the "flange-to-flange" equipment business. These companies also participate in the design and construction activities which, in general, can provide a further business which is equal to or twice that of the flange-to-flange business. Growth rates of 6-8% and 18-20% are anticipated for particulate control and SO_2 control systems, respectively--i.e., an overall growth rate in the order of 8-10%.

TABLE 1-4

ESTIMATED DEMAND AND EMPLOYMENT ASSOCIATED WITH THE SUPPLY OF POLLUTION CONTROL PRODUCTS

(1977 and 1983)

Major PCI Sectors	Level of 1977 Demand (MM$/yr)	Associated Job Equivalents-1977
WPC Equipment	550	11,000
WPC Instrumentation	150	3,750
WPC Chemicals	250	3,850
APC Equipment	700	14,000
APC Instrumentation	50	1,250
Resource Recovery	100	2,000
TOTAL	$1,800	35,850

Major PCI Sectors	Level of 1983 Demand (MM$/yr)	Associated Job Equivalents-1983
WPC Equipment	1,000	12,500
WPC Instrumentation	300	5,000
WPC Chemicals	600	6,000
APC Equipment	1,250	15,600
APC Instrumentation	100	1,700
Resource Recovery	250	3,100
TOTAL	$3,500	43,900

Source: Arthur D. Little, Inc., estimates.

Resource recovery markets have been in the order of $50-$100 million in the last few years. Growth rates should average 15-20% over the next decade--contingent upon the proving of resource recovery technologies in the next two to three years.

The annual employment associated with the 1977 level of demand is estimated at 35,850 jobs; employment is projected to grow (at 3.5% per year) to 43,900 in 1983. Employment projections are based on an overall growth in PCI demand of 11.5% per year but also an 8.0% per year increase in the sales-per-employee ratio. This increase in the sales-per-employee ratio is proportionally the same as that in 1972-77 and assumes that inflation and other business factors will continue to affect the ratio.

Employment estimates are based on average sales/employee ratios developed from groups of leading companies serving each of the PCI sectors. The average sales/employee ratio used for the different sectors of the industry was roughly $50,000 per person. As the demand estimates in Table 1-4 include only those associated with flange-to-flange equipment and other specialty products, the employment estimates are accordingly only those associated with those businesses. They do not include jobs associated with the design and construction of pollution control facilities. Those estimates would be derived from a similar analysis of the consulting engineering business, the fabrication business, and the construction business.

1.2.5 Corporate Commitment and Business Risk

One reason that turnover may be high among PCI companies is that the commitment of some of them to these businesses is waning. Profitability has been disappointing, as some companies expanded their environmental businesses on an opportunistic basis in anticipation of relatively short-term rewards. In addition, the role of proprietary technology has been disappointing. Some companies, therefore, are showing signs of diverting their future investments towards other opportunities, if not getting out of the pollution control business altogether.

A larger number of companies have expressed strong commitments to remaining in these businesses. These commitments are based on a belief in the long-term growth of the business and a satisfactory improvement in profitability.

These businesses are viewed as risky ones by a large portion of the PCI. While legislated markets and Federal funding programs would appear to ensure business volume, PCI companies have found that the enforcement process can affect the timing of that business, and timing can make all the difference.

Risk is further embodied in the requirement of performance guarantees in a regulatory environment of technology forcing standards. Guarantees of system performance across a variety of situations at the frontier of technological practice practically assure some amount of vendor risk, customer disappointment, and enforcement delay. PCI managements simply cannot step away from such contracts, given the healthy competition which exists in most of these markets.

Other elements make up risk for the PCI. It has experienced above average inflation rates--and in 1973-75, against fixed-price contracts. Research and development is risky because it may take five years to develop a new system while regulatory initiatives can bloom or change direction within a year's time. There is the financial risk in the potential overinvestment in people and facilities in anticipation of a demand which may then fade with unrealized legislative deadlines. Although pollution control markets have not followed the general economic cycle, they have their own business cycles and the risks associated with such cycles. Finally, supplier reputations are at risk insofar as they are tied to the operating performance of their products. This performance, in turn, is controlled largely by customers who may not be sufficiently motivated or skilled to properly maintain pollution control systems.

1.3 MAJOR REGULATORY EFFECTS AND ISSUES

1.3.1 The Municipal Bidding Process

The municipal bidding process is the area offering the greatest potential for EPA to have a positive impact upon the health and performance of the Pollution Control Industry (PCI). The current procedures governing the municipal bidding process are widely believed by the PCI to be a major cause of disappointing profitability in the water pollution control business.

The predominance of "low bid" purchasing in the municipal market segment is believed to be impeding technological innovation. It is also believed that "low bid" purchasing will result in expensive operating and maintenance problems for municipal plants in the future.

The widespread practice of (post-award) bid-shopping in the municipal marketplace compounds the problems of "low bid" purchasing. With bid-shopping, there is the possibility that the actual costs of treatment systems are not closely correlated to the award prices paid by municipalities. The federal construction grant program may not be enjoying the full benefits of competition to the degree that the most serious price competition takes place after the construction awards have been made.

A by-product of the current municipal bidding process which should be of concern to EPA is that two grades of products are reported to have appeared in the water pollution control business: an industrial grade and an inferior municipal grade. This development illustrates the predominance of price over performance or technology in this marketplace.

It also reflects a competitive response to bid-shopping practices which are highly sensitive to price differences and relatively less sensitive to product differences.

We have focused on the views of the PCI and have added our own perspective and judgment in this analysis. As these are not the only relevant perspectives, other points-of-view need to be balanced against those reported here. Other interested parties include the municipalities, the consulting engineers, the contractors, the manufacturers' representatives, the materials suppliers, and the federal and state governments.

We are reporting that this remains an area of the utmost concern to the PCI. We are also reporting that there may be competitive, technological, and economic by-products of the current municipal bidding process which were not intended in the legislation (or by its supporting procedures) and which warrant EPA's further attention.

1.3.2 The Role of Federal R&D

A first question is whether there is a need for new control technologies to support current and near-term regulatory initiatives. From the points of view of many in the Pollution Control Industry (PCI), the needed technologies are generally available. Others find that position untenable in a field like pollution control where users will continue to seek lower cost solutions for what are viewed as "non-productive" investments.

If it is accepted that there are needs for new control technologies or control technologies appropriate for new regulatory initiatives, then the issue becomes that of determining the most dependable source of technological innovation.

Consistent with broader Federal efforts to depend as much as possible on the private sector for the development of new and proprietary technologies, EPA's R&D budgets have been declining with regard to the development of new control technologies.

In the case of technological innovation in new pollution control technologies, however, the existence of sufficient motivation and capability in the private sector may be subject to question. The private sector, in this case, may refer to either the PCI or to manufacturing industries seeking to solve their own pollution problems.

Industries seeking to solve their own pollution problems are also the traditional "reluctant customers" of the PCI. This reluctance to purchase pollution control systems may reasonably describe their limited motivation for funding R&D on new control technologies. In short, this largest segment of the private sector provides only a limited foundation for developing new technology in this Federal regulatory area.

The PCI is likewise a limited source of private sector R&D. Leading PCI companies continue to enjoy only average profitability within American industry. While PCI returns are consistent with those for similar manufacturing operations, they have not been conducive to investments in technological innovation. This constraint in motivation is in addition to the historically low level of R&D capability needed by PCI companies in serving their customers prior to the environmental era.

Further, the leading PCI companies are not among the largest companies in our economy. The larger PCI firms are typically in the range of $200-$700 million in annual sales. Their size as well as their recent profitability do not allow for substantial in-house efforts in basic research. Most of their R&D emphasis has become focused upon making refinements to existing technology. Larger, billion-dollar corporations looking to enter PCI markets face the different risks associated with their lack of PCI business know-how. These risks have been reflected in the failure thus far of many PCI ventures by these larger corporations.

An analysis seems thus warranted of the relative merits of Federal support of R&D in pollution control technology versus similar needs in other domestic, non-defense programs. As it stands, existing resources for enhanced technological innovation are questionable if the United States is to depend on its own technical leadership in this area. The increasing importance of foreign technology in the domestic pollution control market seems to underline a diminished pace of U.S. developments.

1.3.3 The Role of Technology Forcing Standards in Air Pollution Control Regulation

The promulgation of more stringent air pollution standards for particulate and sulfur oxide emissions from stationary sources promises to have significant impacts upon the Pollution Control Industry (PCI), raises the possibility of counterproductive effects on achieving and maintaining compliance, and presents some issues regarding the use of technology forcing standards.

In recent years, market instability and delayed enforcement have contributed to disappointing profits and performance for companies in the air pollution control business. Thus far, only a few companies may have made any profit from their participation in the flue gas desulfurization (FGD) segment of the business. Increasingly stringent standards for sulfur oxide emissions will extend the period of uncertainty for FGD suppliers in times of technological capability, operating experience, and market position.

The most stable and profitable part of the air pollution control business has been that of particulate control for utility boilers. The setting of more stringent particulate control standards thus promises to shake up the only sustained business that these companies have known in recent years. By itself, this impact is noteworthy but not sufficient cause for altering regulatory policy.

More important are issues related to the ultimate achievement and maintenance of compliance with these emission standards. These issues arise from an understanding of probable PCI impacts and their derivative implications for regulatory effectiveness.

Just as particulate control has been the steadiest part of the air pollution control business, it has also been the most dependable element of air pollution regulation. The setting of new standards at the frontier of current technological capability might then possibly interrupt the steady progress in particulate emissions control.

Competing at the frontier of technology will require that the PCI overextend their ability to guarantee particulate control performance to a level of little operating experience. At worst, technologies will be "created in the contract" and not in the pilot plant. In short, a substantial number of system failures are likely under these circumstances. System failures may then frustrate regulatory programs by leading to operational problems, by undermining the confidence of users, by providing evidence to reluctant buyers that the systems don't work, by delaying compliance and operation of new utility boilers or by resulting in a net increase of particulates in the atmosphere.

The role of technology forcing standards may differ in a situation--as in particulate control--in which there exists an established and proven technology to control a pollutant to a certain level. Environmental concerns may require higher performance in controlling this pollutant, but a technology forcing standard may be less effective than it is in a situation in which no technology exists to control any satisfactory amount of a pollutant.

1.3.4 System Operation and Maintenance

The main concern for customers of the Pollution Control Industry (PCI) has been to install the systems needed to meet minimum regulatory requirements. In this context, greater emphasis has been placed upon capital investment and appropriate technology, and less attention has been given to eventual operating costs and performance.

As pollution control regulation moves from a stage of "catching up" to one of "keeping up" or even of "keeping ahead," EPA is paying more attention to the maintenance, operation, and performance of pollution control systems. This transition in regulatory focus is likely to uncover many relationships between current pollution control business practices and the long-term operability of pollution control systems.

Several of the issues confronting the PCI hint at some of the problems which may arise in EPA's efforts to regulate operation and maintenance. In the business of resource recovery from solid wastes, the trade-offs between public and private operation of sophisticated systems bear on the prospects for future solid waste management operations. In the air pollution control business, the setting of new emission standards at the frontier of technological capability may reduce the operating dependability of the resulting control systems. In the water pollution control segment, bid shopping and other capital cost-dominated purchasing may work against the operability of municipal sewage treatment plants.

2.0 REGULATORY IMPACTS UPON THE OVERALL PERFORMANCE OF THE POLLUTION CONTROL INDUSTRY

2.1 WATER POLLUTION CONTROL

2.1.1 The Municipal Bidding Process

2.1.1.1 Symptoms of the Problem

Among the general issues we discussed with the Pollution Control Industry (PCI), this one reflects the most concern and emotion within the PCI and presents the greatest probability of a direct detrimental effect of EPA's policies upon the health of this industry.

Several respondents stated that the results of EPA's policies and procedures governing the municipal bidding process represent the single most important problem in doing business in that sector. The form of the bidding process is charged to be one of the major constraints on profitability and supplier incentive across the entire water pollution control segment.

The language was strong. The process was called "a mess," "a disaster," and "a blueprint to destroy an industry." These are emotional exaggerations to make a point, but the important implication is that the situation deserves renewed examination and probably some new policies. These views we have heard are, of course, only those of the PCI. Actually, views on issues in this area vary a great deal even within the PCI. There are other views which are relevant, including those of the muncipalities, the consulting engineers, the contractors, the materials suppliers, the general public, the states, and EPA offices.

On the positive side, the process has clearly encouraged entry by smaller firms. It is argued, however, that low profits resulting from the bidding process are driving out large firms. It is premature to believe that the large, established suppliers are going to simply step away from potential business in the municipal sector. What does seem believable at this time is that corporate commitments to the municipal business are waning.

The industry feels that there is too often an "us and them" attitude at EPA relative to PCI interests in this issue. Very often, they feel they are treated as just another "vested interest"- - almost as if they were a group of polluting industries. Many are pessimistic that EPA can change this atmosphere or these policies in any significant way.

Many of EPA's policies in the construction grants area are seen as sources of further delay in treatment progress. Each new change in EPA policy seems to make the process more complex and, by derivative delays, becomes counterproductive to the intended objectives of greater progress, fairness and specificity. Many of these policies lead to requirements for redesign and to expensive rebids by suppliers.

The latest case in point is the new EPA preferential policy on land applications. While the long-term objectives of that policy are understood within the PCI, there is widespread apprehension over its creating more delays--not only for the sludge handling parts of current projects but for entire project schedules.

All of the above are connected by PCI members to a discouraging marketplace for investing in technological innovation. A lack of consistency in EPA positions from one year to the next works against company investments in new innovations which take three to five years to develop. The differences in construction grant philosophies among EPA regional offices, state agencies and EPA/Washington present another source of frustration and confusion. At the same time, EPA's mandate from Congress to decentralize decision making in construction grants is appreciated.

2.1.1.2 Some Current Procedures

Progress payments are illustrative of a new EPA procedure which was largely instituted in response to PCI concerns and recommendations. All agree that progress payments have helped to reduce the financial risk of providing equipment systems for publicly owned treatment works (POTW's). They have helped the financial performance of the larger equipment suppliers; they have probably helped small suppliers more.

It is reported, however, that progress payment procedures are not being widely applied by municipal grantees. Further, it is reported that contractors have too much discretion as to when to reimburse the equipment companies.

Protest procedures by which suppliers may appeal the decisions in a municipal grant situation are viewed as burdensome. Not many suggestions were offered but the problems include those of slow response and prohibitive expense. The latter problem can be a more critical factor for the new and less capitalized supplier. Of course, the easier the protest procedures are made, the greater the chance of their being overused.

Cost-effective qualification procedures by which a unique system can be specified on a sole source basis are also viewed as too burdensome to encourage their use. A leading supplier of a generally recognized, "innovative" system stated that it had only sold one unit thus far on a "cost effective" basis. Another cited only a half-dozen over an equal number of years.

Manufacturers agree that the most essential item for a cost-justified specification is a consulting engineer with a strong backbone and enduring patience. (It also takes a willing municipality.) The consulting engineer who wishes to pursue this path must stand ready to defend his position again and again. During that process his motives as well as his calculations are subjected to repeated scrutiny. In most cases, the process simply isn't deemed worth the effort.

While many of these procedures may have been designed to enhance competition and reduce the number of closed specification situations, they also present a significant barrier to the stimulation of new technologies. The FWPCA Amendments of 1977 promise to further assist the chances for innovative technologies. Whether associated new procedures will be deemed worth the effort is not yet known.

The posting of performance bonds--designed to enhance entry by competitors without proven experience--is also a significant burden for smaller suppliers. These performance bonds are required because of a concern that unproven suppliers might not stand behind their equipment. The procedure provides recourse to a municipality if a system doesn't work in a given situation, but it also limits how many jobs a small firm can service at one time.

Small suppliers see this procedure as really protecting established suppliers from competition. Established suppliers see it as a minimum step necessary to protect the municipalities from unproven products. It is finally argued that the requirement of a bond does not get at the heart of assuring system capability and workability--i.e., proven performance in a comparable situation.

2.1.1.3 The Bidding Process: The Center of the Problem

The non-restrictive specification requirements mandated by the 1972 FWPCA Amendments has fostered both positive and negative competitive impacts within the municipal marketplace. Among positive impacts, it has shaken some of the "coziness" which existed between consulting engineers and their favored suppliers. It has in that way opened the marketplace to more competition.

It may have also reduced the quality of competition at work in this marketplace. Economics teaches generally that price should be the common denominator and determinant of competitive outcomes. In commodity markets, this simple axiom is workable, but in markets dependent upon technical performance, other factors must be taken into account in the price (or value) equation.

To the degree that "low bid" is the predominant factor in selecting among competitive suppliers of sewage treatment systems, the rewards for superior performance and other technical advantages are minimized. Yet, municipal treatment plants are technical systems, and the marketplace will continue to need improved systems.

The open specification requirement and its concomitant low bid emphasis are believed to inhibit technological innovation. Manufacturers see little chance of reward for proprietary technologies and view the system as favoring purveyors of low or bare minimum technologies. It essentially encourages the minimum system available at a minimum price to do a broadly defined job.

One related frustration of suppliers is that the detail of the bidding process often seems to be more important than the final workability of the system. The nonrestrictive specification process does not sufficiently ensure (although it may allow for) the importance of serviceability, the availability of spare parts, etc.

The issues here are not so much the amount of competition or the number of competitors that have entered the business. The issues are the quality of competition and the nature of the products which are chosen for a community's sewage treatment needs. Fairminded members of the PCI acknowledge the good effects and purposes of the non-restrictive regulations but they are concerned over some of the side effects of the manner in which they are now being implemented in this marketplace.

Bid shopping is the practice by which the contractor (who has received the award associated with a construction grant for a fixed price) reopens the bidding among equipment suppliers. Through bid-shopping, a contractor may seek to reduce his actual costs (by playing alternative suppliers of each equipment system off against one another) below his estimated costs at the time of award. It is not surprising that a contractor can be successful in reducing the costs of equipment systems. These cost savings, however, are then enjoyed by the contractor and not by the municipality or the Federal Government.

It is also not surprising that the equipment suppliers have learned not to provide their best shots (i.e., best price) at the time of the award. They may be motivated to "do right" by each contractor, but they don't yet know who the successful contractor is going to be. The selection of the successful contractor--made on the basis of total plant cost--may have very little to do with the cost of an individual component. In any case, equipment suppliers have learned to save their lowest prices for the "serious business" of the final decision when the successful contractor goes bid shopping.

Contractors, too, have learned that equipment suppliers cannot be expected to give their best quotes at the time of award. They have learned to discount the quotes according to their experience in bid shopping and their desire to get a job. One can suspect that a hungry contractor can be easily tempted to exaggerate the discounts that he can expect to receive. When it comes time to prove these assumptions, his desire to make a profit within a low bid budget is likely to produce arrangements not in the best interests of the public sector.

Our concern here is that municipalities, the Federal Government and the public are not receiving the full benefits of the competitive process which EPA regulations have worked to ensure. When a municipality awards a contract to the contractor with the lowest price, there is now only a very tenous relationship of that price to the eventual cost. The competitive process has simply not run its course at that point. The public sector has a firm price based on an infirm cost picture.

Dealing with the bid shopping problem requires understanding when the competitive process actually begins as well as when it ends. Before EPA's open specification regulation, a large part of the competition took place in the form of pre-selling and pre-engineering efforts provided by equipment suppliers to consulting engineers. Suppliers still had to be price competitive in order to preserve their investment in assisting the consulting engineering firm and in educating him on the advantages of a proprietary (or "unique") system.

Currently, competition still takes place at the Step 1 (planning) and Step 2 (design) stages as suppliers attend to the information needs of consulting engineers. In a competitive market of differentiated products and legitimately different technologies, this process remains important to an effective dissemination of information and a quality level of competition necessary in a technical marketplace.

The present "low bid" and "bid shopping" system reduces the reward for the pre-selling investment. In the present system, the suppliers who invested in assisting the design of the plant are not dealing with the same party at bid shopping time. Contractors have less reason to appreciate that a particular piece of equipment has been sized and designed to fit the rest of a unique plant. Consequently, they will entertain quotes from companies who will supply an off-the-shelf item and who do not have to recover the costs of earlier pre-selling.

The nonrestrictive specification regulation has done a lot of good; yet, we believe the market behavior and procedures which have evolved from it needs reexamination. There are just too many aspects of it that threaten the best interests of public funding, future plant operation, and--finally--a healthy pollution control supplier industry. The intensity of competition does not have to be sacrificed, but the game playing which is only confounding the situation needs to be eliminated. It could be argued that EPA has no business making further regulations to improve the competitive process. It could also be argued that it is an EPA responsibility, given that it has already impacted that process.

2.1.1.4 Suggested Procedures and Solutions

Prequalification is one suggestion favored by some PCI member companies. This procedure allows for the municipality or consulting engineer to be persuaded (by experience or other evidence) that competing suppliers are capable of providing workable systems. Current EPA regulations allow for the use of prequalification rules at the discretion of state and local authorities but do not either mandate or encourage the practice. A major objective of this suggestion is to eliminate the chances of unqualified companies winning contracts and not delivering on them. It is believed that pre-testing requirements would not be too expensive for most suppliers. Other companies, particularly the smaller ones, see this suggestion as discriminating against them. It is also seen by some as a means of sidestepping the nonrestrictive specification regulation. Yet, the present form of that regulation is exactly what seems to be causing problems.

Life cycle costing is another suggestion which speaks to the tendency of the present system to overemphasize the low initial cost of a system. Life cycle costing is usually seen only in Step 1, although it may be used in Step 2 as well. In Step 1, the decision is that of choosing between alternative technologies before putting out a specification for a prefered technology or its equal. Manufacturers report that considerations of life cycle costs are rarely employed at the Step 3 stage. At this point, the decision is usually between different suppliers of similar systems. In bid shopping, it is logical that only initial costs are important to a contractor as he works to bring total costs under his bid price.

It is assuredly easier in theory to justify a life cycle costing approach from Step 1 through Step 3 than it is to implement it in practice. Operating costs and lives of systems are not as well documented as initial costs, as it is more difficult to confidently estimate operating costs. Accordingly, it will not be difficult for suppliers without documentation to claim to be competitive with those that do have operating experience with their systems.

The "write-in bid form" or "listing" has been suggested as a means of combating the destructive competitive effects of bid shopping. Basically, this approach (which is allowed but not required under EPA regulations) limits the selection of a final supplier to those listed by the contractor at the time of award. The major objective of this approach is to eliminate at least the freedom of the contractor to search out an unknown quantity to fulfill subcontracting needs.

"Buy American" regulations are, relatively speaking, a minor issue at this time. Before the EPA interpretation of the 1977 Amendments was issued, however, there was some concern that almost every domestic company could be impacted negatively by a narrowly defined interpretation. Most companies in the PCI now see a Buy American restriction as more of a problem than as an assist to their business--this despite the fact that many such companies lobbied for such a provision in the 1977 Amendments.

Some inconsistency is seen between a Buy American clause and the fact that EPA's funding of R&D on control technologies have declined. The importance of foreign sources of new approaches has been increasing. Consequently, almost all domestic suppliers have built relationships with foreign companies for technologies, components, or packaged systems.

The Buy American restriction is best seen as a help to the domestic industry if it is used to guard against foreign-based suppliers of entire systems which can exploit a low-bid competitive situation from a basis of little experience.

2.1.1.5 Roles and Responsibilities

A nagging issue is that responsibility for eventual system operation seems to rest tenuously among the parties which have participated in the building of a POTW. In practice, contractors see their responsibility ending shortly after the plant is operating. Equipment failures after that point are deemed to be the vendors' problem. Equipment suppliers sense that they will be left holding the bag because their nameplate is still attached to the equipment. This is an uneasy responsibility in a situation where a low-bid process has forced them to design a system close to the minimum and where associated systems purchased in a bid shopping process may not work together to specification. The consulting engineering community is seen as taking less and less responsibility for the system now that so much of its authority over the design has been taken from it. With no clear remaining candidate for responsibility in this situation, it is likely to fall by forfeit to the municipality itself.

Some contractors may be clearly qualified to make the technical judgment necessary to decide between competing equipment systems. In some cases they may be more qualified than the municipalities or as qualified as the consulting engineers. The problem is that, generally speaking, the typical contractor is not professionally trained in wastewater treatment technology. Yet, in the present system, these nonprofessionals are making technical decisions on (i.e., selections of) suppliers and systems. As described above, the factors which are now most likely to influence these decisions are price, price, and price. The final decisions on equipment systems and the suppliers of those systems, therefore, appear to lie with the wrong party.

The more appropriate party to make the purchase decision would appear to be either the municipality or the consulting engineer--if everyone can agree that EPA (or the Corps of Engineers) and the states should not be involved in this aspect of the business. In the case of large- and medium-sized municipalities, the chances are good that their professional staff could better make this selection. In other cases, the consulting engineer would appear to offer the best source of professional experience and up-to-date knowledge needed to make this decision.

It is reported by the manufacturers that consulting engineers on the whole have lost a great deal of their interest and professional pride in this field. They may now have little interest in a return to some of their previous authority and responsibility. It is reported that many have learned to simply take the easy way out--write an open specification, allow for a broad range of equal systems, and design to minimum requirements. In short, they are not really choosing to exercise their full professional judgment, even though EPA regulations do not preclude them from doing so.

The business now seems in need of a better process for the final selection of equipment systems. Professional training and ongoing experience seem to qualify the consulting engineer for a renewed and greater role in assisting a municipality to make that selection.

2.1.2 The Industrial Market Sector

The impacts of EPA policies and regulations upon the industrial part of the water pollution control business are mostly covered in the general issues in Section 2.4 below. Delays and uncertainties in the enforcement process are the biggest problems faced by suppliers tc the industrial market. Eventually, pretreatment regulations and user charges for municipal wastewater treatment services will have significant effects upon the industrial business.

PCI spokesman report that the industrial buyer is typically less tolerant of unqualified equipment suppliers than their municipal counterparts. This difference varies among companies, among industries, and between new source and retrofit situations. Purchasers of retrofit equipment for existing plants tend to behave most like the municipal buyer. Their primary objective is to minimize added investments to what may be an old facility. Their interests in eventual performance may be minimal. In new source situations there is a greater chance that an industrial buyer will be concerned about equipment life and operating performance.

The Industry reports that EPA's technology transfer conferences have been useful. They may be more directly of use to their industrial customers, but they also provide a good forum for exchange of information.

It is believed that EPA studies of appropriate technologies have helped to stimulate industrial use of new approaches. One example of this is the activated carbon work sponsored by EPA/Cincinnati. Generally, the industry feels that the use of advanced waste treatment technologies has been as much a result of its own marketing efforts.

2.2 AIR POLLUTION CONTROL

A general issue that came up a few times (but certainly not from a broad spectrum of our interviews) was the interface or relationship of EPA policies to the policies of the other non-environmental, federal and state agencies. Illustrative of such a problem are situations in which the costs of SO_2 control have not been allowed by state power commissions to be included in the rate base. There are instances of fly ash being outlawed as an aggregate on a local basis. There is also believed to be a need for a more uniform approach to the disposal of sludges from FGD systems across the country.

2.2.1 Standard Setting Practices

The major concerns for the impact of EPA policies and regulations upon the air pollution control business are in the standard setting area. Certain regulations promulgated by EPA are seen as unattainable or impractical. The regulations for incinerators were oft-cited as examples of regulations which ask for performance beyond the capabilities of present analytical and control technologies. The technical basis for the setting of air pollution control standards is often not clear--in this case to an industry which is quite capable of understanding a technological rationale.

Some in the industry see problems with percent removal regulations. A common view is that emission-type regulations (related to Btu's or weight rates) are much easier to measure and administer than percent removal standards. There is some concern, too, that the percent removal requirements associated with Western coals are partly motivated by political and not environmental reasons. The question has been raised as to whether there aren't better ways to resolve the political issues than through pollution control regulations.

2.2.1.1 Frequency of Sampling

EPA is presently working to increase the frequency of emission sampling from power plant stacks. Interesting questions about this change were raised from the basis of text-book statistical analysis and production control methodology. Depending on the nature of the statistical variation in power plant emissions, the discussion below suggests the possibility that more frequent sampling and feedback control adjustments could result in higher average emissions.

For example, in production line management, one can reduce material usage by continuous sampling of a product sheet. The production foreman may then gauge production targets closer to the tolerance (e.g., thickness) limits of the product. There is greater control over the manufacturing process; the manufacturers use less material (on a weight basis); and the customer ends up getting a more uniform product.

In the emissions sampling context, we have a kind of "inverse" of that production situation. There appears to be no natural impetus for industry to institute more frequent sampling, but EPA may require it. With less frequent sampling, a polluter can be argued to set his operating target sufficiently below the maximum allowable emission level so as to avoid excursions that would result in a citation and a fine. Reducing the sampling interval may be argued to encourage a polluter to raise operating targets closer to the maximum allowable emission level and still avoid instances of non-compliance.

As a result, the long-term average net pollution might be greater under a "more controlled" case than under the previous regulatory approach. This does depend upon the nature of the variation in stack emissions. More frequent sampling may still be desired in order to gain more intelligence for the agency in determining compliance. Also, regulatory policy may prefer somewhat higher average emission levels in return for reducing the frequency of detrimental excursions as well as increasing the chances of catching non-compliance.

2.2.1.2 Technology Forcing Standards

This remains an important concept in EPA's regulation of air pollution. The concept has been particularly important in the development of regulations governing mobile source emissions. Its greatest usefulness appears to be in situations where technology does not appear to be available to do a job which is environmentally necessary.

Our discussions with PCI representatives in the air pollution control field lead us to question the continued appropriateness of a technology forcing standard approach in situations where technology already exists to control a given pollutant to the level of a current standard and where the next objective is to achieve greater removal of that pollutant.

Probably the best current instance in which to examine the appropriateness of a technology forcing approach is in particulate control.*

More stringent emission standards for particulates will have selective effects upon competitors and competitive technologies. Specifically, electrostatic precipitators (ESP's) have been proven for some time in the utility industry. In recent years, many domestic manufacturers have had to adopt foreign or new versions of ESP's in order to meet increasing efficiency requirements and the conditions created by lower sulfur fuels. But, in general, particulate control technology is established and its application has stabilized. Now there is the chance that future standards could simply be out of reach of the ESP technology.

The best candidate to accomplish greater efficiencies of particulate removal in power plants is the baghouse. Until recently, baghouses competed with ESP's mainly in manufacturing industry applications. It has taken the new emphasis upon flexibility of operation with different fuel mixes and increased efficiency standards to open the door to the utility market for baghouse technology. But the technology cannot yet be considered proven in this application.

Bag life has always been one of the major economic constraints of baghouse use, and the experience with bag life in utility installations may by itself determine the competitiveness of baghouses in the utility market. Further, some respondents have pointed out that the earlier demonstrations of baghouse performance have come in smaller power plant installations. They are yet to be proven in larger power plants or across a broad range of coal-fired situations--although many such units are now under contract or construction.

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*The industry does not expect EPA to establish standards for NO_x, for example, beyond what can be accomplished through combustion approaches. It does not appear that EPA will press for NO_x control to the extent that end-of-stack approaches are required. SO_2 control may represent another situation in which to examine the approach, but it really remains an area of developing technology.

If the emission standard (on a lbs/MM Btu basis) is set at such a level that only baghouses can possibly achieve the desired result, then there is a great regulatory risk if baghouses don't work according to their projected dependability or economics.

We have asked industry representatives about the relative competitive position of ESP's and baghouses (excluding scrubbers from this consideration although they, too, have potential roles) at different levels of standards. At .08 lbs/MM Btu (down from the current standard of .10), there would appear to be no real opportunity for baghouses to make a significant penetration of the market. At .05, there would be limited baghouse success and continued dominance by ESP's. The standard of .03 elicited some difference in opinion; some felt that it would make for an "even horse race" between the two technologies, and others felt that it would essentially put ESP's out of business. Baghouses were believed to have the market all to themselves if .01 were chosen.

If the driving force for a more stringent standard is an environmental necessity--for example, the removal of submicron particulates which may have serious human health effects--then the technology forcing approach might again be relevant to this standard setting area. If, on the other hand, the driving force is simply to keep the standard at the frontier or slightly ahead of current or best available practice, then there may well be detrimental effects: upon the confidence of the utility buyer in the ability of new systems to meet the more stringent requirements; within the air pollution control equipment supply industry; and more importantly, upon the maintenance of particulate control in the country.

The air pollution control industry already has little stability upon which to plan, invest, and take voluntary risks. Competition in the emerging FGD sector of the business is sufficient to make us wonder whether any single supplier has yet to make any money in that business. The industrial air pollution control (APC) market is too diffuse to offer a secure future to individual suppliers. Individual equipment suppliers can typically claim good knowledge of only selected industrial (i.e., non-utility) markets. The future potential for industrial air pollution control is not known well because of the early stages of regulation extant in most industrial markets.

The heart of the APC equipment business has long been the control of particulates from utility power plants by ESP's. With the catching up on the retrofitting of existing power plants, the outlook for ESP sales is already clouded. If sufficiently stringent standards are set so that ESP's cannot compete any longer in that market, the effects within the APC business will be great and the threat to continued, confident particulate control is real.

A real problem here from a PCI point of view is the lack of stability. Moving standards proscribe the development of confidence in consistent performance from one plant to another. They may also provide reluctant customers with ammunition with which to delay decisions and with which to later say, "I told you so."

It was suggested to us that the current effect of such technology forcing requirements for particulate control is that technology is being "invented" in the contract rather than in a pilot or analogous facility. In this competitive business, a supplier must choose to make guarantees he cannot be sure of or retreat from the marketplace.

The phenomenon of "technological breakthroughs" through the medium of "contractual promises" does not bode well for the eventual operation and performance of APC facilities. A counterproductive result of an increased standard is thus possible where neither the customer nor the supplier is on familiar ground. The systems (built at minimum competitive cost but with guaranteed performance) may not work. The penalties for not delivering on the guarantee may well be realized in terms of dollars, but they cannot be recouped in terms of pollution control efficiency, on-stream availability, or technical reputation.

This may only be one side of the problem seen from the perspective of this study. The possibility of these downstream effects, however, deserves serious consideration before a heretofore stabilized situation is disrupted.

2.3 RESOURCE RECOVERY

This is the one industry sector where EPA is known to have relied to some degree on the PCI for advice and counsel. At that, it is only an emerging industry sector--one interested in the recovery of energy and materials from municipal solid waste streams. EPA has, for example, instituted technical assistance panels which employ some PCI participants in counseling municipal and regional authorities.

We have heard some complaints by the industry that EPA has had too much of a direct effect on the business in its embryonic stages. There is a sense that EPA (a'la municipal sewage treatment) is, for example, also pushing municipalities towards a "low price" mentality (as opposed to a price/performance approach) in what is still an area of developing technology. Some report an "us and them" attitude in apparent EPA preferences for municipal ownership of facilities (as opposed to private ownership). This is assumed to be based on the simplistic logic that it is cheaper for a non-profit operation to supply these services than it is for a profit-making one.

Unlike the municipal sewage treatment market sector, however, EPA clearly does not exert a strong influence on decision-making in this business. Manufacturers feel that a large part of the progress in this business is up to them, and that that is the way they prefer it.

Policy preferences were occasionally suggested during our discussions. It is believed that loan guarantees will help to stimulate the resource recovery industry. Faster write-offs on the order of 8-10 years versus 30 years and other tax incentives would be of assistance to companies looking to build, own and operate these kinds of facilities.

To some degree, solid waste separation legislation and regulation will hurt the economics of centralized resource recovery systems. There are also problems with some state laws which constrain municipalities from agreeing to long-term contracts with private firms and which further require that decisions be made solely on a "low bid" (as opposed to a price/performance) basis.

2.4 GENERAL ISSUES

2.4.1 EPA Policy Impacts

Many impacts upon the PCI were similar in water pollution control, air pollution control, and resource recovery. Most PCI spokesmen agreed that any incentives which would encourage customers to comply and purchase equipment systems would be welcome. At this time, tax incentives are considered to be the only significant assist of this kind.

EPA's plans to make the cost of non-compliance (through penalties) equal to that of compliance are viewed enthusiastically. Some difficulties are seen with this program in terms of its implementation. One suggested refinement would be to make sure that the penalties are set to exceed the cost of compliance. There was another suggestion that EPA further explore avenues of allowing earlier compliers to do less and requiring foot-draggers to do more--such a system would be the inverse of what is seen to result from the present regulatory framework.

Failure to follow through on anticipated enforcement has discouraged many suppliers of pollution control systems and cooled the interest for further investment by them in these markets. Situations where EPA and/or the states embark on a well-publicized program to clean up an industry by a certain date and then are not able to follow through on that threat are the most frustrating (as they probably are to the regulators).

Delays are particularly disrupting to the planning of these companies. Unrealistic targets are seen as contributing to unnecessary delays in many instances. Each time that a realistic or unrealistic compliance date is missed, more incentive is given to future foot-draggers.

Another common kind of delay is the one caused by a change in EPA policy or administration. The industry has come to expect these kinds of delays and to patiently wait for them to settle out.

The problems of changing regulations are seen in terms of both consistency and the "ratcheting" of standards. Consistency is seen by some as second only to the lack of enforcement among the impacts which EPA policy has upon the industry. Different EPA Regions interpret EPA policy differently. Policy interpretations change with new leadership. PCI customers, on the other hand, have a need to know whether a system will suffice for five to ten years and would prefer, of course, that it suffice for the life of a new plant.

Generally speaking, the PCI prefers industry-wide standards (i.e., emission standards) as opposed to those which attempt incrementally to improve on each situation (i.e., such as ambient air quality standards).

The problem of "ratcheting" standards takes many forms. Improved measurement capability is seen as one cause of such "ratcheting," even though that capability may go beyond the effectiveness of control technologies or the known effects of lower pollutant levels.

A history of ratcheting of pollution standards is seen to impede commitment by pollution control customers. A common customer concern is that a successful pollution control installation will be quickly ratcheted across all of a company's plants and across an entire industry. Customers are often reluctant to be such pioneers.

Moving standards are also seen as a problem in a regulatory effort that seems to take on problems one at a time. A complaint is that regulators often move on to a new problem before the enforcement of regulations covering an earlier problem or a lesser level of control has been completed.

2.4.2 EPA/PCI Relationships

Experience varies within the PCI but interactions generally seem less frequent than they should be--although this seems to be improving. Some companies follow programs of keeping contact with EPA as a source of learning about new developments and new problems/opportunities. Other companies have begun to increase their contacts with EPA Regions when specific purposes arise. A large portion of the industry has little or no contact with EPA. There is also a significant group that specifically avoids visible association with EPA because of possible adverse reaction from its customers.

Interested PCI members often feel that they have one of the smallest voices in influencing EPA decisions--this in contrast to the relevant expertise which exists in the PCI. Some respondents have noted that in contacts with EPA, they are often treated as just another "vested interest." Some leading companies claim that EPA has never, to their knowledge sought their counsel on anything.

In another vein, many participants have received significant benefits from the use of EPA information, and they report that they have found EPA staff to be generally responsive to requests for information.

3.0 REGULATORY IMPACTS UPON THE PURCHASE AND OPERATION OF POLLUTION CONTROL SYSTEMS

3.1 THE PURCHASE DECISION

3.1.1 "Reluctant and Embarrassed Customers"

An outstanding characteristic of the pollution control business has been the "reluctant customer." Aside from a few situations in which pollution control systems are anticipated to provide greater benefits, the costs of pollution control are viewed by "reluctant customers" as non-productive investments. Non-productive investments tend to be deferred until regulatory pressures are brought to bear.

Pollution control system suppliers find themselves identified by the customer with these unwanted expenditures. Companies in other markets know that it is easier to sell to a customer who can look forward to saving money as a result of a purchase. Selling pollution control is a delicate process designed to not make the customer feel pressured to: 1) do it any faster than he has to; 2) do it any more than necessary; or 3) do it "better." All of this also takes some of the usual psychic reward out of the selling experience.

Another hybrid of the reluctant customer is the "embarrassed customer." The "embarrassed customer" may be one who worries that if a control system actually works in one plant, it will then become a standard requirement on other facilities. Such a customer may be concerned that his plant may be the first in the industry to achieve a level of cleanup and that EPA will use that experience to require similar systems and compliance from others in the industry. However, this could well provide a competitive advantage for this customer. A common embarrassment is one felt within trade associations--particularly when the facility is cited in support of new regulatory standards. The "embarrassed customer," in short, is not particularly anxious to make a new technology work and is also not terribly anxious to talk about it if it does.

3.1.2 "Double Standards"

We have explored the extent to which there is a "double standard" between how industrial customers buy pollution control systems and how they buy process systems. With some exceptions, spokesmen for the PCI have found their pollution control customers to be less concerned with life cycle costs, equipment life, and dependability than their process counterparts.

A few large manufacturers are reported to be placing as much importance on long-term operation of pollution control systems as they do on the rest of a new facility. These customers appear to be the exception rather than the rule.

With the general trend from a retrofit to a new source business, many suppliers foresee an erosion of the double standard; but most suppliers are skeptical that current practice has moved very far away from it. One factor which would accelerate the trend would be greater EPA emphasis on the operability of these systems. It is difficult to understand how EPA might affect the purchase decision more directly.

Another factor which will improve this situation is the growing influence of environmental vice presidents and departments within the corporation. As pollution control becomes more an accepted part of doing business, the responsibility, the professionalism, and the influence of these environmental "gurus" will start to be seen in the purchase decision.

Large pollution control customers are thought to be more interested in buying a better piece of equipment than their smaller counterparts. To the degree that initial cleanup efforts have focused on larger corporations, the larger backlog of retrofit associated with smaller facilities will provide extended life to the "reluctant customer," to the "low-price decision," and to the "double standard."

3.1.3 "Free Engineering"

As "free engineering" is an important part of selling municipal sewerage systems, it is also a factor in the municipal purchase decision. In the industrial market, the amount of front-end or free engineering provided to a prospective pollution control customer is reported to be similar to that provided with selling process equipment.

To the degree that consulting engineers now have less responsibility in the municipal sector, the amount of free engineering (and possibly, therefore, the quality of design effort associated with the municipal plant) may logically have declined in recent years. Wastewater treatment suppliers are certainly less interested in providing that free engineering or in emphasizing that marketing approach.

3.1.4 Decision Factors

Before giving any other impression, we wish to acknowledge categorically that price is the most important factor affecting pollution control purchase decisions. The greatest problem in this technological market is that price may too often be the only factor. The primary purchase objective is one of minimizing the price to meet the minimum regulatory basis for compliance.

Price is usually associated with the capital expenditures or initial costs of a pollution control system. Less frequently, customers are known to use life-cycle or annualized cost approaches to the purchase decision. Given the delay between the time that a purchase decision is made and the time that it may be installed (particularly in the utility and municipal markets), price escalation clauses are a common practice in today's market to allow for inflationary effects. It was not common practice a few years ago when the shortage of energy and raw materials raised prices to the point where pollution control equipment suppliers lost money on their backlog of contracts. If factors other than price have any importance in the purchase decision, their influence is usually constrained within a competitive range of prices.

One non-price related factor which may affect the customer's decision is tradition. Tradition will also lead customers to purchase systems with which they have been satisfied in the past. They may also favor suppliers who have proven themselves in previous situations or who have broad reputations in the field. Generally speaking, large companies tend to buy from larger suppliers and smaller companies tend to be a better market for new or smaller suppliers.

A customer may rely heavily on the recommendations of a consulting engineer, a neighboring plant, or a contact within an industry association. Recommendations of EPA or other regulatory bodies were not cited as a major influence in purchase decisions.

The importance of energy in the purchase decision is increasing and varies from market to market. Air pollution control systems tend to be more energy intensive. An air pollution control customer, for example, will take into account the kind of fuel to be used as he chooses an SO_2 control system. In resource recovery, energy is both a cost and a benefit of the system. As energy is the most highly valued resource to be recovered from municipal solid waste systems, energy is obviously important to system selection. Water pollution control systems, on the other hand, are not very energy intensive; purchase decisions tend not to be made on an energy basis in that market sector. The exceptions to this in wastewater treatment are thermal destruction approaches for sludge disposal or other terminal treatment steps.

Other "intangibles" do affect purchase decisions but do not consistently carry a lot of weight. Performance, flexibility, reliability, serviceability, and economic benefits are these non-price factors which play less important roles.

3.1.5 Regulatory Impacts

It is possible that EPA policy should have more bearing on what factors are considered in the purchase decision. It is not clear how EPA could directly impact the purchase decision. (Indeed, one school of traditional wisdom says that EPA should stay out of something that close to the competitive process.) On the other hand, some trigger points of influence are apparent. More emphasis on the operation and maintenance of pollution control systems would work to change the calculus of the purchase decision. Incentive systems which would reward greater levels of control with economic benefits hint at another route of influence.

A current negative factor related to the purchase decision lies in the rebids often required in the municipal sewage treatment and utility air pollution control markets by changing regulatory groundrules, multi-step review processes, and delays. In air pollution control systems for utilities, for example, bids or rebids cost from $40-$100,000 apiece.

3.2 SYSTEM OPERATION AND MAINTENANCE

3.2.1 Water Pollution Control

EPA is already concerned that insufficient attention is being given to the long-term operation and maintenance of municipal sewage treatment works. The genesis of some of these problems lies in the design and purchase decisions of the municipal plant itself. "Low-bid" thinking "buys" potential operating problems. While capital expenditures for municipal plants are largely funded by the Federal Government, operating costs become the responsibility of the municipality. Hence, unless regulators are diligent in the enforcement of permits, there is an economic incentive for municipalities to first minimize the operating costs--which may be inconsistent with peak system performance. Maintenance procedures are also likely to suffer.

One important EPA innovation has been allowing for the use of grant monies towards the initial operation and shakedown of new municipal plants. The industry agrees that this is one step towards better system performance and better operator understanding.

Operator skills will probably always be a problem in the municipal sector. Municipal sewage treatment plants are not profit-making operations and hence, there is no incentive to staff a facility with needed technical skills. EPA training programs have helped to fill a major gap in this regard.

Responsibility for system operation remains a critical problem in the municipal sector. As the bidding system is now constituted, responsibility may lie with the town by default. Wastewater treatment equipment suppliers do expect that municipalities will try to call on them when problems occur. Otherwise, the responsibilities of the consulting engineer have been reduced, and contractors only feel responsible for getting a system up and running.

Operating performance and system maintenance are typically more important to industrial customers, although that is only a matter of degree. The minimization of initial costs is still the most important factor to the retrofitting of existing industrial facilities. Vendor responsibility in the industrial sector is often tied to a performance or system guarantee.

Probably the most haunting comment we heard regarding the future operation of WPC systems was that two grades of products are being sold: an industrial grade, and a lesser municipal grade. This practice has partly evolved in response to the "low bid" priority and the "bid shopping" process in the municipal market.

3.2.2 Air Pollution Control

3.2.2.1 The No-Bypass Idea

One possible regulation would require that a pollution control system be integrated into the process in such a way that the process is not operable unless the control system is operable. The FGD business is an illustration of a market in which there is some precedent for this kind of approach. As a result of utility choice or indirect regulatory pressure, systems have been built (or are now under construction) without bypasses so that the boiler must be shut down if the control system goes down.

We received a range of views from within the PCI regarding the practicality of such a "no-bypass" administrative regulation. Those who believed it practical noted that individual utilities are already requiring it in some of the project specifications. Others believe that EPA must use this kind of approach if it was to achieve greater reliability and on-stream time for FGD and particulate control systems. Experience to date would appear to teach that system availabilities are higher in situations having no built-in bypasses to the pollution control system.

A somewhat larger group believed that the no-bypass approach was not the best way to solve the problem of reliability and availability. These people were concerned that the general public would be the one to suffer. They were not sure EPA would want to be seen as the cause (or cited by utilities as the cause) of major power shortages. This group tended to favor the use of non-compliance penalties as a means of encouraging greater reliability and diligence in operation.

The use of the pollution control system itself as a built-in bypass is not usually practical because the conditions of hotter and more abrasive gases would destroy much of a pollution control system. One interesting idea was that of a bypass of limited capacity. This would allow partial operation in a crisis situation and provide incentive to get the entire unit up and running.

In any case, the PCI appreciates the need for incentives to insure continued operation of pollution control systems. There is no question that a no-bypass approach provides such an incentive.

3.2.2.2 A Possible Manpower Problem

A potential regional problem was mentioned by a couple of respondents. It is a possible manpower problem associated with the development of coal resources in the West and the power plants associated with those resources.

It is partly a pollution control driving force that influences the siting of power plants in the immediate vicinities of Western coal resources. In theory--leaving prevention of significant deterioration (PSD) constraints aside--this reduces increased net pollution in urban regions where power plants have been traditionally located.

The location of major power plants in the rural areas of the West also requires that operating personnel take up residence in those areas... and like it. Air pollution control equipment suppliers report they are already fighting problems of getting skilled people to locate in these areas even for construction and start-up periods. They extrapolate this initial experience into a broader problem facing pollution control from these facilities in the future. The hypothesis is that it will be difficult to keep skilled people needed to operate both the power plant and the pollution control system in these remote areas. Hence, this trend in power plant siting may, for this one reason at least, tend to produce more net pollution from less well-operated facilities.

3.2.2.3 The Placement of Responsibility

The best place for the responsibility of air pollution control system operation is believed by the PCI to lie with the industrial or utility customer. From their point of view, it is the customer who chooses his system on the basis of price, has control over the procedures by which they are operated, and chooses the site of the plant in the first place. Air pollution control systems suppliers continue to feel somewhat powerless in assuring eventual operation of their pollution control system. So much is up to the utility and the boiler end of the operation.

Within utility organizations, the responsibility for the making of the initial purchase decision may lie with the engineering department, or an outside consulting engineering firm. In larger utilities, the engineering department tends to have more influence than the purchasing department. In smaller utilities, the purchasing department, and possibly a consulting engineer, is likely to be more important than an internal engineering staff.

A source of possible responsibility in the future may lie in the hiring of outside contractors by utilities or industries to own and operate the pollution control facility for a fee. There has been no significant move in this direction in the marketplace, but the possibility is still there. It has been observed many times that utilities, for example, do not want to be in the "chemical business" associated with many FGD systems. Potential outside contractors do worry that this part of the operation might be subject to regulation by public utility commissions. Also, the operation of the pollution control facility is so dependent upon the operation of the process or the boiler that responsibility for emission levels would still be difficult to resolve.

3.2.3 Resource Recovery

The major issue relative to the operation of resource recovery facilities is whether public or private ownership and operation of these facilities will dominate. If public ownership becomes prevalent, then the responsibility for operation will lie with a municipal or similar authority. This will be true particularly if responsibilities for the construction and start-up of the facility were spread among many parties, i.e., between a consulting engineer, equipment supplier, and a contractor.

If private ownership prevails, and the owner and operator are one party, then the source of responsibility is clear. An intermediate situation is the private operation of a system that was built by a municipality, designed by a consulting engineer, and purchased from an outside supplier. It is not clear that such an operator has responsibility for a system that doesn't work; nor is it clear that the supplier or consulting engineer has responsibility when performance clearly depends upon operating practices.

One of the more important aspects of responsibility in resource recovery is the danger inherent in the nature of municipal solid waste streams to the operation of the plant and the safety of its personnel. The wide variety of materials, wanted and unwanted, which often appear can be more safely accommodated in a sanitary landfill. When it comes to processing this waste with heat, compaction, or chemical reactions, the need for careful management of a resource recovery facility is clear. One existing facility, for example, reports that four people are employed full time simply to watch the conveyors leading to the processing stages. This is another factor which may influence the general choice between municipal operation (of a non-profit making facility) and a private profit-making operation.

4.0 CHARACTERIZATION OF DEMAND

4.1 WATER POLLUTION CONTROL

4.1.1 The Business Environment

The water pollution control (WPC) equipment market can be divided into two distinctly different submarkets: municipal sewage and industrial wastewater. Each of these markets supports suppliers of specialty equipment, instrumentation, and chemicals, all of which will be briefly characterized in this section.

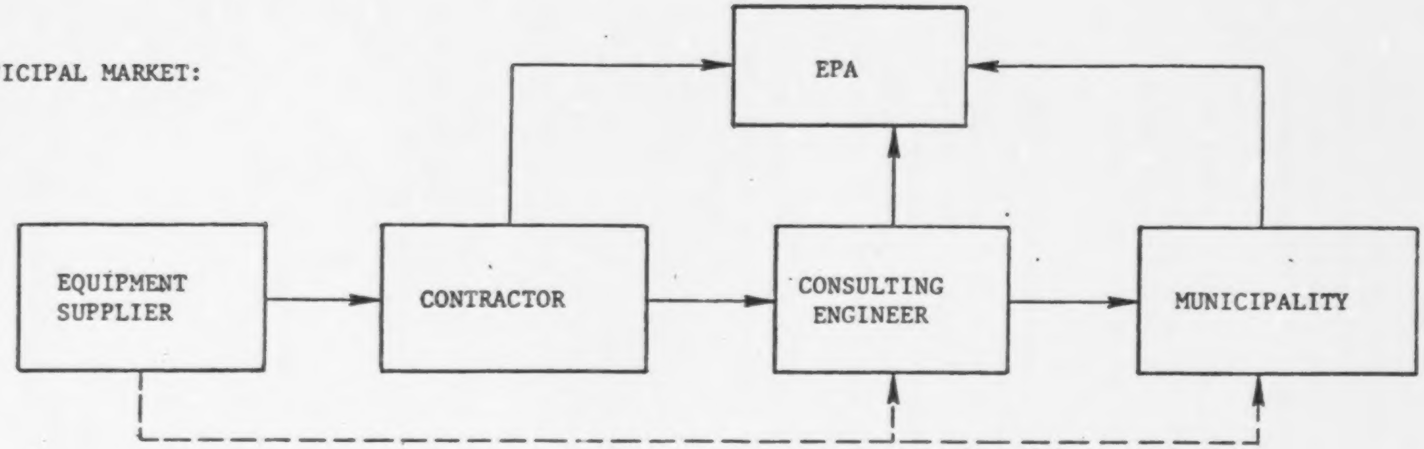
Perhaps the major difference between the municipal and industrial markets is the type of sale. The municipal market follows the traditional "plan and spec" approach taken by the consulting engineer and contractor. Equipment suppliers respond to written specifications which place priority on low bid. In comparison, the industrial market is more of a "negotiated" market. The relationship between the equipment supplier and the end-user is more direct, and the purchaser may consider the supplier's reputation, performance, responsiveness, etc., in the purchase decision.

A comparison of the roles of different participants in both markets is shown in Figure 4-1. In the municipal market, the equipment supplier generally receives his orders from a contractor, who in turn has responded to an open bid developed by a consulting engineering firm on behalf of a municipality. "Preselling" by the equipment supplier may be focused on several participants: the consulting engineer, the municipality, the contractor, and occasionally the EPA. To serve the municipal market, most manufacturers rely upon either direct salesmen or manufacturers' representatives. The municipal market--particularly as it involves new and innovative technologies--is characterized by a considerable amount of "free engineering" in the preselling effort.

In the industrial market, the independent consulting engineering firm is not as prominent, and the supplier's technical assistance is generally focused toward the customer's internal design staff or the contractor. The industrial market presents a more straightforward marketing structure to the equipment supplier, but he may have to call on a mix of captive design staffs, selected consulting engineering firms, and contractors.

The regulatory driving forces for WPC equipment markets rests within five Federal statutes beginning with the original Federal Water Pollution Control Act (FWPCA) of 1948 and followed by the Amendments of 1956, 1961, 1966, 1972, and most recently, 1977. The 1956 FWPCA Amendments established the present Municipal Grants Program, one of the largest public works programs ever undertaken by the Federal Government. The program will now provide roughly $4.5 billion annually under the 1977 Amendments, and is intended to account for 75% of the Nation's municipal sewage plant construction requirements. In the municipal segment, the major driving force has been--and will continue to be--the availability of these Federal subsidies.

MUNICIPAL MARKET:


EPA
EQUIPMENT SUPPLIER
CONTRACTOR
CONSULTING ENGINEER
MUNICIPALITY

INDUSTRIAL MARKET:

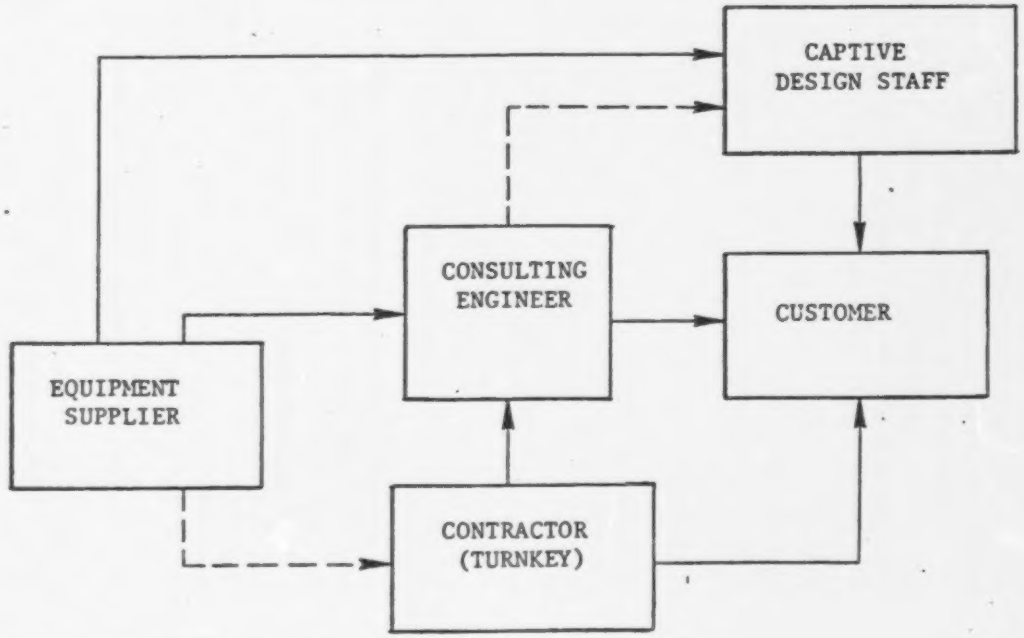

CAPTIVE DESIGN STAFF
CONSULTING ENGINEER
CUSTOMER
EQUIPMENT SUPPLIER
CONTRACTOR (TURNKEY)

FIGURE 4.1 - MUNICIPAL AND INDUSTRIAL MARKETING INTERFACES

Unfortunately, appropriations and obligation of Federal funding has not always matched Congressional authorizations (Figure 4-2). This was particularly true during from 1973 to 1975 when expenditures fell far below the Congressional authorizations in the 1972 Amendments because of Administration impoundments. However, it should be noted that all but about $50 million of the $18 billion authorized under the 1972 FWPCA Amendments was obligated by the end of fiscal year 1977.

In the municipal segment, this lag in Federal expenditures has created a considerable amount of disenchantment in the WPC industry as is noted elsewhere in this report. Even now, the industry appears to have experienced only moderate growth over the past 24 to 30 months, and major suppliers report that bookings are again down.

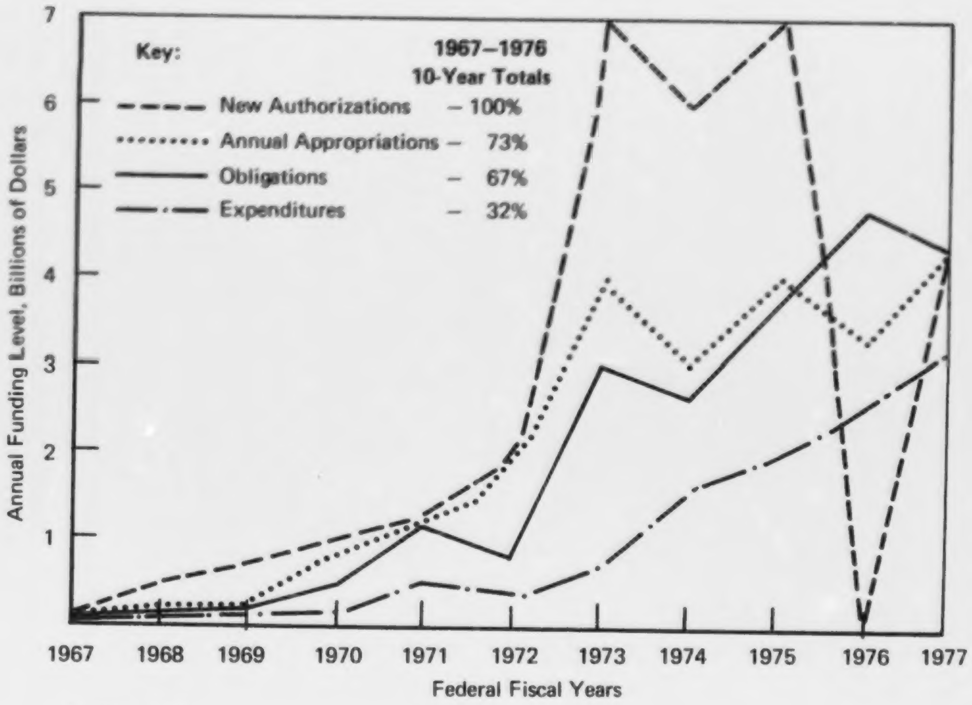
The regulatory driving forces in the industrial sector are vastly different, as no Federal funds are involved. Industrial demand for WPC equipment is driven by the enforcement actions taken by EPA and state regulatory authorities. EPA analyses in mid-1977 indicated that approximately 85% of industry was in compliance, i.e., with permits by the July 1, 1977 deadline for BPT treatment. We believe that the proportion of industrial plants which have yet to actually implement BPT controls was probably double the 15% suggested by the EPA analysis.

Equipment suppliers geared toward serving the municipal market often do not do well in the industrial market. A major problem is the actual identification of specific customers, a difficult task for smaller suppliers offering only selected WPC product lines. Both large and small equipment suppliers find it difficult to maintain an extended coverage of different industries on a national basis. Those equipment suppliers that have done well in the industrial market have: 1) generally offered other types of industrial process equipment; 2) focused upon selected industries; and 3) sold through direct sales forces to situations where their success and reputation can be used to full advantage.

New driving forces in the municipal, and, to a lesser extent, the industrial markets will result from the 1977 Amendments. While it is difficult to accurately determine the downstream effects, some preliminary implications can be drawn. Suggested impacts include the following:

- Municipal suppliers of "innovative and alternative technology" will benefit from greater Federal subsidies (85% or more). These technologies may include various land treatment schemes, oxidation ditches, rotating biological contactors, oxygen aeration systems, filter presses, and possibly automation systems.

- Equipment suppliers offering energy conservation technologies will also benefit. Examples might be digesters and rotating biological contactors.



Source: EPA.

FIGURE 4.2 HISTORICAL LEVELS OF FEDERAL GRANTS FOR MUNICIPAL WASTEWATER TREATMENT PLANTS

- Equipment and instrumentation schemes focused toward water conservation will also be favored and may be eligible for additional subsidies.

- New and innovative alternative technologies appear broad in definition, and include "alternative to conventional" systems. Once a more concise definition is offered, it could encourage sludge disposal systems designed for horticultural or agricultural land application.

- Additional emphasis is to be placed upon the life-cycle cost of conventional treatment systems, particularly where an innovative technology promises to be at least 15% less costly than the most cost effective, conventional alternative. This formally recognizes the emerging concern inside EPA regarding equipment performance after the plant has been installed

- Suppliers offering equipment, largely monitoring and analysis instrumentation, which provides for better management of toxic materials would participate in an expanded market of undetermined size and centered on the detection and abatement of hazardous discharges.

- Equipment suppliers incorporating American-made materials ("Buy American") will be favored.

There may be some negative impacts on equipment suppliers resulting from the 1977 Amendments. The law suggests that EPA will undertake additional steps in reviewing and authorizing Municipal Grants applications. Whether this increased infrastructure will affect the scheduling and disbursement of obligated funds is not clear.

A major issue centers around the "small community" in which a central collection system and sewage plant may not make "economic sense" in relation to alternative nonstructured approaches. Alternative approaches include, but are not limited to, septic tanks, surface disposal systems, honey wagons, other onsite systems, and small package treatment plants serving clusters of residential uses. Potentially, these developments could transform the type of opportunities associated with small municipalities, and decrease the equipment sales potential associated with a central treatment plant. The 1977 Amendments also placed further limitations on plant size by defining the amount of growth allowable in treatment plant planning and construction.

The Amendments also redefine the role of the industrial user of municipal treatment systems by setting forth more specifications concerning user charges and payment schedules. The extent to which this might affect the smaller industrial market cannot be determined at this time.

Similar to the policy undertaken for the EPA's air pollution control programs, the 1977 Amendments generally promote the delegation of regulatory responsibilities to the individual states. This continues a longer term trend by EPA in fostering local review and decision-making. The implications on specialty equipment and instrumentation suppliers are mixed. If such state delegation duplicates what has occurred in air pollution control, the net effect might be to further weaken the industrial market.

Finally, the extended deadlines for municipal and BAT compliance will tend to draw out equipment demand, possibly resulting in declining growth rates. Possibly offsetting this will be the emphasis on toxics which may require improved treatment systems.

4.1.2 Municipal Specialty Equipment

The general health and long-term outlook for WPC equipment markets may be gauged by the backlog of equiment required to meet existing regulations. For many years, these investment requirements have been reported by EPA in its periodic Municipal Needs Survey (Table 4-1). The latest (1976) survey indicated a backlog of slightly over $150 billion in 1976 dollars. Specialty equipment markets represent only a fraction* of this investment and are generally confined to that investment required inside the treatment plant (EPA Categories I and II). These categories were most recently estimated to be $34.3 billion in 1976 dollars.

One advantage of the Federal funding commitment is the compilation of detailed statistics on municipal treatment requirements to be derived from the Needs Survey. Interestingly, most equipment suppliers have not made serious efforts to develop useful market information from EPA's data base. Either they are not familiar with the format, are confused by the size of the Survey itself, and/or are generally unaware of the value of the data. In an attempt to better understand the municipal equipment requirements, we examined the municipal market backlog in some detail.

We first attempted to rank individual treatment processes in terms of their remaining backlog. This was measured by calculating the amount of "adequate" capacity installed as of 1976 as a percent of needs required by 1990. This ranking is summarized in Table 4-2. Not surprisingly, primary treatment processes and some secondary treatment processes are relatively mature markets. Processes involving tertiary treatment are the least mature and may have the strongest growth--depending upon EPA's future funding priorities.

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*Specialty equipment suppliers generally receive about 10-12% of total municipal treatment plant expenditures; instrumentation suppliers generally account for 2-5%.

TABLE 4-1

MUNICIPAL WATER POLLUTION CONTROL INVESTMENT REQUIREMENTS
(billions of 1976 dollars)

Category		
I	Secondary Treatment*	13.0
II	More Stringent Treatment*	21.3
IIIA	Infiltration/Inflow	3.0
IIIB	Replacement and/or Rehabilitation	5.5
IVA	New Collector Sewers	17.0
IVB	New Interceptor Sewers*	17.9
V	Combined Sewer Overflows	18.3
	TOTAL I-V	96.0
VI	Control of Stormwater	54.1
	TOTAL I-VI	150.1

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*Categories covered under EPA's Municipal Grants Funding Program.

Source: Environmental Protection Agency, 1976 Needs Survey.

TABLE 4-2

COMPARATIVE BACKLOGS FOR SELECTED MUNICIPAL TREATMENT PROCESSES

Rank	Treatment Process	Remaining Requirements* (mgd)	Installed "Adequate" Capacity as a Percent of Needs Required Prior to 1990 (%)
1	Two-Stage Tertiary Lime	420	1
2	Biological Nitrification	3,930	2
3	Activated Carbon	880	3
4	Biological Denitrification	920	4
4	Ammonia Stripping	390	4
4	Filtration	11,810	4
7	Breakpoint Chlorination	140	14
8	Activated Sludge	19,800	34
9	Oxidation Ponds	2,250	35
10	Disinfection	16,300	38
11	Trickling Filter	2,580	41
12	Preliminary Treatment	10,530	53
13	Primary Sedimentation	8,920	54

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*Includes both installed plant capacity which will require improvement and new plant capacity which is needed, but not yet funded. Needs are in millions of gallons per day (mgd).

Source: Arthur D. Little, Inc., based upon EPA's 1976 Needs Survey.

Table 4-3 summarizes the estimated backlog--totalling approximately $2.1 billion--of municipal equipment required to comply with the goals of the 1972 Amendments.* The derived distribution of the $2.2 billion of identified equipment backlog appears reasonable; that is to say activated sludge, incineration, dewatering, digestion, and filtration appear to represent the major market opportunities. In addition to the equipment identified in Table 4-3, we were able to identify, but not assign, other equipment needs as follows:

	$ Billions
Identified Equipment Needs	2.146
Unassigned Needs	.109
Other Unidentified Treatment	.118
TOTAL	$2.373

Figure 4.3 graphically illustrates the distribution of flange-to-flange equipment needs between existing plants and new plants through 1990. The long-term market would appear to be evenly divided between existing and new plants.

Figure 4.4 indicates a market that is more focused toward smaller sized plants than those that have been built in the past. For example, 60% of total equipment backlog is located in plants which have a nominal flow of 0.25 mgd versus about 40% of existing plants in this size range. The importance of these smaller plants in the backlog makes equipment suppliers susceptible to changes in EPA policies regarding small municipal treatment plants--particularly any policies that might affect the type of abatement systems utilized by these smaller facilities.

During this analysis, an as-yet-unresolved discrepancy arose regarding the EPA data. A comparison of the 1976 Needs Survey requirements with the ADL estimates based upon a more detailed review of the Needs Survey resulted in a significant gap in equipment backlogs. Assuming an industry recognized average specialty equipment value of 10-12% of treatment plant requirements, it was estimated that between $3.8 and $4.6 billion of equipment will be required based on a total investment backlog of about $38 billion in 1978 dollars. However, the process-by-process ADL analysis could identify but $2.4 billion worth of equipment. Discussions with EPA staff resulted in somewhat reducing the macro-estimate; however, the two estimates remain significantly different.

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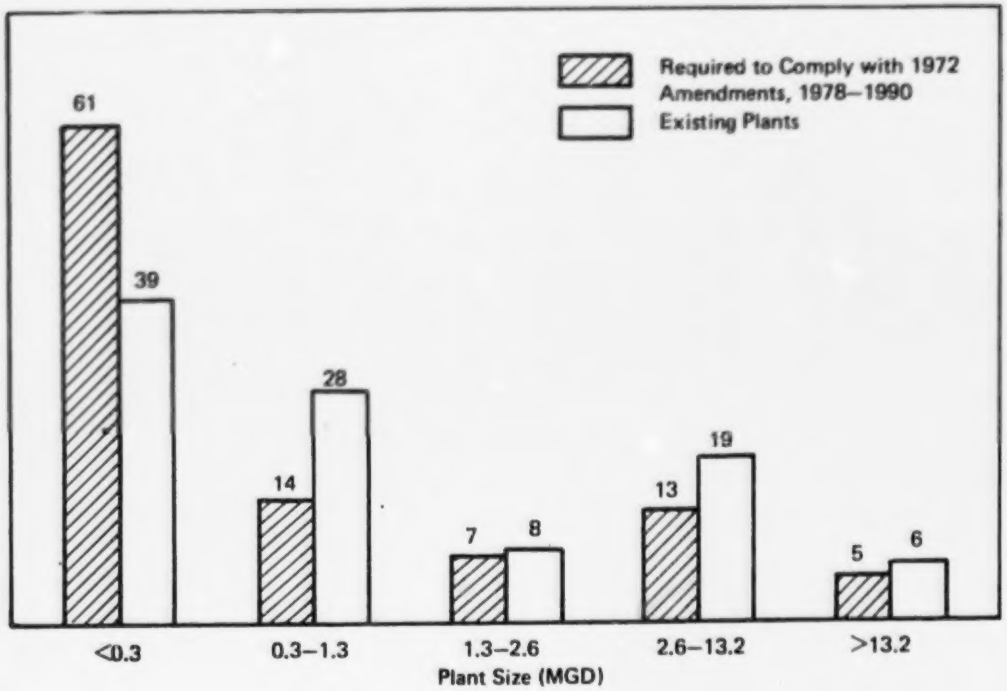
*More detailed data regarding these and subsequent estimates are given in the Appendix.

TABLE 4-3

MUNICIPAL WATER POLLUTION CONTROL
SPECIALTY EQUIPMENT REQUIREMENTS - 1978-1990
(millions of 1978 dollars)

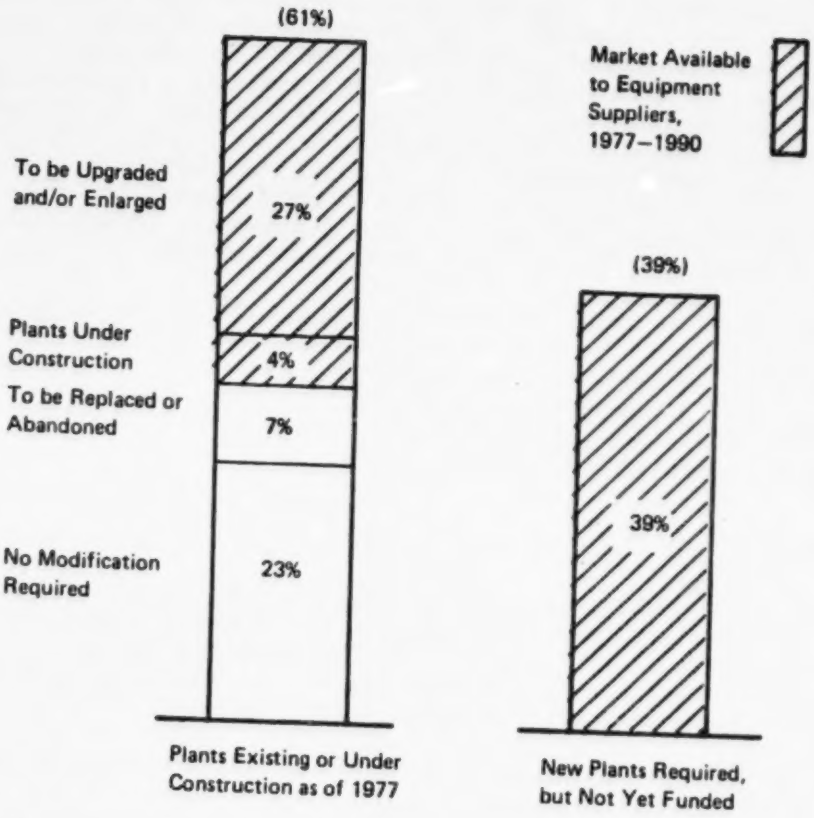
Range	Process
>$700	Activated Sludge
$250-$400	Incineration Dewatering
$100-$250	Anaerobic Digestion Filtration Trickling Filter
$50-$100	Sedimentation Disinfection Pumping Activated Carbon
>$50	Preliminary Treatment Tertiary Lime Nitrification Denitrification Chlorination Ion Exchange Ammonia Stripping Heat Treatment

Source: Arthur D. Little, Inc., estimates based on EPA's 1976 Needs Survey.



Source: Arthur D. Little, Inc., estimates based on 1976 Needs Survey.

FIGURE 4.3 - COMPARATIVE DISTRIBUTION OF MUNICIPAL WPC EQUIPMENT VALUE BY SIZE OF PLANT (percent)



Source: Arthur D. Little, Inc., estimates based on 1976 Need's Survey.

FIGURE 4.4 - PROFILE OF MUNICIPAL WPC EQUIPMENT INSTALLATIONS, 1990

We estimate that the 1977 shipments of municipal water pollution control equipment totaled $295 million ($325 million, including pumps) and were distributed as shown in Table 4-4.

The outlook for different segments of the municipal market varies by type of equipment. Conventional treatment equipment should show a moderate near-term growth rate of between 10 and 12% annually. Of course, certain types of equipment (such as rotating biological contactors) should outperform the market as a whole but only in cases where such equipment is gaining market share relative to alternative technologies. Dewatering equipment for municipal applications should grow more rapidly (12-14%) than for other specialty equipment. In fact, sludge handling and disposal may be the most secure market of the 1980's. Large thermal equipment systems will generally be confined to plants in excess of 10 mgd flow, and should show an annual average growth of between 10 and 12%.

WPC equipment suppliers are shown in Table 4-5 and consist of major suppliers which generally offer broad product lines and participants with selected product offerings. During the 1970's, there has been a gradual trend towards greater industry concentration. In 1973, we estimated that the 20 largest suppliers accounted for approximately 60% of industry shipments versus an estimated 75% in 1977.

4.1.3 Industrial Specialty Equipment

Investment in WPC equipment has represented a significant percentage of industrial capital plant investment over the past several years. This has been directly caused by Federal regulatory pressures associated with the 1977 deadline for BPT. As a result, the industrial WPC equipment market exceeded its municipal counterpart until last year.

The measure of long-term potential for industrial WPC equipment is again EPA estimates of required equipment backlog. EPA conducts a number of ongoing studies of industrial WPC requirements including economic impact studies, guideline support studies, and other industry analyses. Table 4-6 summarizes different estimates of required industrial wastewater treatment expressed in billions of 1978 dollars. Sources include EPA, the National Commission on Water Quality, the National Bureau of Economic Research (under contracts to EPA), and the Council on Environmental Quality. The EPA-sponsored studies are generally in agreement that between $11 and $15 billion was required by 1977 by industry to meet the BPT standards. An additional $19 billion or so will be required to meet the BAT standards. The estimates of pretreatment requirements vary significantly because the lower estimate ($2 billion) excludes two critical industries incorporated into the larger estimate ($6.7 billion). The backlog of specialty equipment is probably represented by 15% to 25% of the estimates in Table 4-6.

Estimates of industrial equipment requirements by industry illustrate that the investment is spread across a variety of industries and industrial processes. Estimates made by EPA generally fall below similar estimates made by industry trade groups.

TABLE 4-4

1977 SHIPMENTS OF MUNICIPAL WATER POLLUTION CONTROL EQUIPMENT AND ESTIMATED GROWTH THROUGH 1983

	Shipments ($ millions)	Growth (%/yr)
Primary, Secondary and Tertiary Treatment	142	10-12
- Activated Carbon Columns		
- Aeration		
- Aerobic Digestion		
- Ammonia Stripping		
- Anaerobic Digestion		
- Chemical Feeders		
- Chlorinators		
- Disintegraters		
- Flocculation		
- Flotation		
- Nitrification/Denitrification		
- Oxidation Ditch		
- Oxygen Aeration		
- Rotating Biological Contactors		
- Screens and Degritters		
- Trickling Filter		
Thermal Treatment	129	10-12
- Heat Treatment		
- Open Hearth Incineration		
- Fluid Bed Incineration		
Dewatering and Filtration	24	12-14
- Plate, Frame, and Vacuum Filters		
- Belt Filters		
- Filter Press		
SPECIALTY EQUIPMENT	295	10-12
Pumps (in-plant only)	30	
TOTAL	325	

Source: Arthur D. Little, Inc., estimates based on discussions with industry contacts.

TABLE 4-5

WATER POLLUTION CONTROL EQUIPMENT COMPANIES

Major Competitors

Envirotech
Ecodyne
Rexnord
FMC
Pennwalt
Neptune International
Dorr-Oliver
Peabody International

Other Participants

General Signal
Union Carbide
Infilco Degremont
Chicago Bridge and Iron
Autotrol
Sterling Drug
Crane
Zurn
Passavant
Clow
Carborundum
Dresser Industries

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*Industry-by-industry estimates are shown in the Appendix.

Source: Arthur D. Little, Inc., estimates.

TABLE 4-6

COMPARATIVE ESTIMATES OF REQUIRED INDUSTRIAL WASTEWATER TREATMENT INVESTMENT, 1977 CAPACITY

(Adjusted to Billions of 1978 Dollars)

Source	Year of Estimate	BPT (1977)	BAT (1983)	Pre-Treatment
Environmental Protection Agency • Cost of Clean Water • Guidelines Development Documents • Economic Impact Studies	1973-1976	11.0-13.4	--	--
Environmental Protection Agency • Internal EPA Memo[b]	1977	14.3	19.4[a]	2.0[c]
National Commission on Water Quality • NCWQ Final Report	1975	43.0	27.1	--
National Bureau of Economic Research • EPA Contract Study	1976	14.4	--	6.7
Council on Environmental Quality • Eighth Annual Report	1977	39.9		--

Other private-sector sources of detailed estimates on specific industries include:

- The Conference Board
- American Iron & Steel Institute
- American Paper Institute
- American Petroleum Institute

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[a] Includes New Source (NSPS) investment through 1985.

[b] Memo of June 24, 1977, entitled "Costs of BPT, BAT, NSPS, and Pretreatment for Testimony."

[c] Excludes the electroplating and machinery and mechanical products industries.

Source: Arthur D. Little, Inc., estimates.

TABLE 4-7

ESTIMATED BACKLOG OF INDUSTRIAL WATER POLLUTION CONTROL INVESTMENT

(billions of 1978 dollars)

	BPT (1977)	New Source Through 1983	BAT (1983)	Pretreatment
Required Investment as of 1973	14.3	7.4	12.0	2.0
Less Expenditures, 1974-1977	10.1	3.0	Nil	Nil
Investment Remaining	4.2	4.4	12.0	2.0

Source: Arthur D. Little, Inc., estimates based upon EPA data.

TABLE 4-8

1977 SHIPMENTS OF INDUSTRIAL WATER POLLUTION CONTROL EQUIPMENT AND ESTIMATED GROWTH THROUGH 1983

	Shipments ($ millions)	Growth (%/yr)
Primary, Secondary and Tertiary Treatment	208	8-10
- Activated Carbon Columns		
- Aeration		
- Aerobic Digestion		
- Amonia Stripping		
- Anaerobic Digestion		
- Chemical Feeders		
- Chlorinators		
- Disintegraters		
- Flocculation		
- Flotation		
- Nitrification/Denitrification		
- Oxygen Aeration		
- Rotating Biological Contactors		
- Screens and Degritters		
Thermal Treatment	2	8-10
- Fluid Bed Incineration		
Dewatering and Filtration	55	8-10
- Plate, Frame, and Vacuum Filters		
- Belt Filters		
- Filter Press		
SPECIALTY EQUIPMENT	265	8-10
Pumps (in-plant only)	45	
TOTAL	310	

Source: Arthur D. Little, Inc., estimates based on discussions with industry contacts.

individual methodologies used by EPA in arriving at the BAT estimates, it is possible that the investment required may be overstated. To that extend, the industrial market may show decreased growth.

ADL estimates that the overall near-term growth outlook for industrial WPC equipment will be within the range of 8-10%. Industrial WPC equipment suppliers (same as shown in Table 4-5) should find their best near-term markets in the steel, primary metals, and power industries.

4.1.4 WPC Instrumentation

Water pollution control instrumentation has generally been provided by a group of instrumentation companies serving many other industries and problems. Like specialty equipment, the municipal market for instrumentation has depended upon Federal grants while the industrial market has resulted from regulatory enforcement policies.

Instrumentation expenditures are a relatively small percentage of total plant expenditures as illustrated below:

		Percent
Municipal Treatment Plant		2-5
Secondary Treatment		
Monitors and Controls	3	
Analyzers	1	
Secondary Treatment with Automation		5-8
General Process Industries		6-10

In those municipal plants where computer automation is installed, instrumentation expenditures can be as much as 8% of the total plant (including conventional instrumentation); hence, automation represents a significant market segment for WPC instrumentation.

It is difficult to make an accurate estimate of instrumentation backlog. If one assumes that instrumentation for the municipal segment will average 5% of treatment plant expenditures (previously estimated to be $38 billion in 1978 dollars), then approximately $1.9 billion of instrumentation requirements remain. In the industrial sector, if one assumes an average of 9% for instrumentation (in the previous investment backlog estimates of $2.9 and $4.2 billion), remaining equipment needs total between $0.3 and $0.4 billion.

WPC instrumentation markets in 1977 were approximately $145 million (see Table 4-9), most of which was in the municipal sector. The bulk of this is accounted for by conventional control systems (approximately 60% municipal and over 80% industrial). Analytical instruments account for an additional 10% within each of these markets. Computer automation accounts for about 25% of the municipal market and less than 10% of the industrial market. In the municipal market, there are additional instrumentation markets available to suppliers beyond those which lie inside the treatment plant.

Placing the WPC instrumentation market in perspective, 1978 expenditures for all instrumentation for analysis and control will be approximately $10.5 billion according to the Department of Commerce. Of this, slightly less than half is for domestic shipments and $1.6 billion of that is accounted for by process control. WPC instrumentation shipments collectively account for only $150 million, or a relatively small segment of the total market for process control instrumentation.

Instrumentation markets may exceed the growth of the market for specialty equipment. Market leverage lies in the increasing penetration of automation within both the municipal and industrial markets. However, there are several negative influences within the municipal segment including:

- no incentive for municipal plants to improve effluent quality;
- no statutory penalty for discharge violators;
- lack of trained or skilled plant operators; and
- general unfamiliarity of design engineers with online instrumentation.

On the positive side, automation systems have been fostered by the continuing reduction in digital computer costs, innovative uses of microprocessors and chip technology, and the continuing Federal grants for plant construction which have indirectly encouraged supplemental expenditures for controls. Nevertheless, municipal plants are generally behind American industry in the adoption of automatic process control. Although past installations of automation in the municipal sector have been on large plants, there is a growing trend of application to moderately sized plants. Automation will probably not be a realistic alternative for small municipal plants.

We estimate a 12-14% annual average growth rate for the municipal market. This is greater than the growth rate for WPC equipment due to both the increasing penetration of automation systems and the anticipated demand for instrumentation to detect and monitor toxics and other hazardous materials in the waste streams. Our growth estimate for industrial WPC instrumentation may be somewhat conservative given the increasing focus on toxic discharges.

TABLE 4-9

1977 WATER POLLUTION CONTROL INSTRUMENTATION MARKETS AND GROWTH OUTLOOK THROUGH 1983

		Current Market $ millions)	Growth Outlook Through 1983 (%/year)
Municipal		105	12-14
Monitoring and Control	65		
Analysis	15		
Automation	25		
Industrial		40	10-12
Monitoring and Control	35		
Analysis	5		
Automation	--		
	TOTAL	145	12-14

Source: Arthur D. Little, Inc., estimates.

Major WPC instrumentation suppliers are shown in Table 4-10. Fischer & Porter and General Signal (BIF) are the recognized industry leaders mainly on their strength in the municipal markets.

4.1.5 WPC Chemicals

In comparison to the equipment markets, the market for water pollution control chemicals is a "razor blade" or "consumables" business. Neither is it directly dependent upon the Federal grant program. This total market is generally divided, both characteristically and by type of supplier, into either bulk or specialty chemicals.

Any discussion of the WPC chemical market must note that the wastewater treatment demand for such products is far less than the water treatment demand for similar chemicals. The application of chemicals for the control and recycling of wastewater from municipal or industrial facilities follows the more traditional business of chemicals applications for influent water treatment.

The municipal water treatment market has traditionally been one of bulk chemicals (i.e., alum, chlorine, etc.)--one which has shown traditionally moderate growth. Specialty chemical opportunities include markets for coagulant aids, neutralization and filter aids, disinfection, biological compounds, and activated carbon. In contrast, the industrial water and in-process treatment market is heavily oriented towards specialty chemicals. Markets exist for ion exchange resins, zeolites, chelating agents, scale and corrosion inhibitors, algicides, and bactericides.

Bulk chemicals are typically supplied by larger integrated chemical companies, and the wastewater treatment chemical business represents only an adjunct to their total annual chemical sales. The customized activity in WPC chemicals lies with specialty chemicals suppliers. The market positions of major specialty chemical suppliers--some of which are smaller subsidiaries of larger companies--have been built in the water treatment business where technical know-how and market coverage have served to enhance their market positions.

The specialty chemical companies are often viewed as "water doctors." That is to say they are called in both to diagnose and to suggest remedies for treatment problems. Product differentiation among the chemicals themselves is largely achieved through product formulation. In most cases, suppliers are more appropriately labeled formulators rather than basic chemical manufacturers. Technology, except for the proprietary formulations, is not much of a factor.

Customers generally purchase a considerable amount of technical service along with the specialty chemicals themselves. The market is characterized by long, established relationships between suppliers and their customers, particularly industrial customers.

TABLE 4-10

WATER POLLUTION CONTROL INSTRUMENTATION SUPPLIERS

Fischer & Porter
General Signal
Betz
Beckman
Leeds & Northrup
Foxboro
Great Lakes
Johnson Controls
Taylor
Honeywell
Technicon

Regarding profitability, the specialty chemical business has long been the outstanding performer of the environmental industry. This has been noted in the financial section of this report.

The legislative driving forces have been indirect and have historically drawn upon the FWPCA and its subsequent Amendments. However, recent laws have or should soon offer additional opportunities for suppliers, particularly specialty chemicals. Two examples are the Clean Drinking Water Act and the Toxic Substances and Control Act.

External factors affecting the future of WPC chemicals include the Nation's increasing concern over water conservation. Also, in the area of water supply, pending EPA regulations may create significant new markets such as those for activated carbon. Another factor is industry's increasing emphasis on changes in process technology which may be required to meet the more stringent BAT standards. More emphasis will be placed upon treating and recycling in-plant water in lieu of end-of-pipe treatment.

We estimate the 1977 market for water and wastewater treatment chemicals approached $900 million (Table 4-11). Only $240 million, or 27%, of this was in wastewater treatment for both municipal and industrial facilities. The remaining $650 million was in water treatment. Of the two, the wastewater treatment markets--particularly the industrial market--should have the higher growth rate. The municipal water treatment market will have the lowest growth rate, something on the order of GNP growth, discounting any impacts of inflation. Likewise, specialty chemicals should grow at a rate greater than bulk chemicals.

We forecast a growth rate for overall water and wastewater chemical markets of about 12-14% per year. This should be exceeded in both industrial wastewater treatment (18-20%) and in municipal wastewater treatment (14-16%). Within each of these areas, the outlook for specialty chemicals is stronger still, with growth rates of greater than 20% and 15%, respectively.

A final influence on the recent growth of industrial specialty chemicals for WPC has been the attitude of industry on installing more expensive WPC treatment facilities. Industry has generally been reluctant to undertake large capital investment in WPC equipment, and as a result, has often turned to chemical treatment as a solution to wastewater problems.

Table 4-12 lists WPC specialty chemical suppliers. We estimate about 50% of industry sales are accounted for by the major competition shown, sometimes referred to as the "Big Six."

TABLE 4-11

ESTIMATED WATER AND WASTEWATER TREATMENT CHEMICAL MARKETS, 1977

($ millions)

	Bulk[a]	Specialty[b]
Municipal Wastewater Treatment	60	45
Industrial Wastewater Treatment	60	75
Subtotal Wastewater	120	120
Municipal Water Treatment	130	55
Industrial Water Treatment[c]	85	380
Subtotal Water	215	435
TOTAL	335	555

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[a] Bulk chemicals include chlorine, alum, lime, soda ash, ferric chloride, ferrous sulfate, clays, and salts, among others.

[b] Specialty chemicals include coagulant aids, ion-exchange resins, slimicides, bactericides, activated carbon, and corrosion inhibitors, among others.

[c] Includes both influent and in-process treatment.

Source: Arthur D. Little, Inc., estimates.

TABLE 4-12

WATER POLLUTION CONTROL SPECIALTY CHEMICAL SUPPLIERS

Major Competitors

Nalco
Betz
Calgon (Merck)
Drew (U. S. Filter)
Dearborn (W. R. Grace)
Mogul (Dexter)

Other Participants

Westvaco
ICI
Rohm & Haas
Dow
Sybron
Illinois Water Treatment
Culligan

4.2 AIR POLLUTION CONTROL

4.2.1 The Business Environment

The APC equipment marketplace most closely resembles the industrial WPC equipment marketplace. The major driving force is regulatory enforcement. The APC equipment market is commonly divided into either particulate control or gaseous control equipment. The gaseous control market includes several lesser known pollutants such as nitrogen oxides, but the current market is focused on the sale of flue gas desulfurization (FGD) systems for control of sulfur oxides (SO_x) from power plants.

The particulate control market is a mature market. Current sales are largely related to new sources, with the remaining backlog of retrofit business being expired at a slower pace than during the 1970-1975 period. The leading product has been the electrostatic precipitator which has been long established within the electric utility industry. Fabric filters, or baghouses, are second to electrostatics in terms of annual shipments. Less efficient mechanical collectors and scrubbers (for particulate control) represent still lower shipment values.

Characterizing the market by end-use, there is a major distinction to be made between the electric utility industry and the remaining manufacturing industries. Electric utilities represent the major market for FGD systems. Non-utility industrial customers have represented roughly half of the market for particulate control systems. Indeed, certain industries will require FGD systems and other gaseous control equipment (incinerators and absorbers). While shipments of FGD equipment have increased significantly in recent years, particulate control equipment continues to dominate the market.

The regulatory driving forces behind the air pollution control sector are based on the Clean Air Act of 1963 and the Clean Air Act Amendments of 1966, 1967, 1970, and 1977. EPA has been able to pass APC enforcement responsibility to the individual states. The long process on the part of individual states to draw up their implementation plans (SIP's) is nearly over, with many lingering exceptions.

The 1977 Clean Air Act Amendments along with a 1974 Supreme Court ruling on the definition of "significant deterioration," may significantly increase the potential markets for established suppliers. Likewise, emerging EPA policies on "tradeoffs" within a particular region may further shift the particulate market to new source installations.

The market for APC equipment is closely tied to individual state attitudes on enforcement. Those states which encompass several noncompliance regions or which have been rigorous in pursuing their enforcement options have created good localized markets. However, in those cases where states have been lax, APC equipment shipments have been disappointing and most suppliers have been unable to sell equipment to "voluntary" customers.

Marketing organizations differ somewhat between the particulate and gaseous control market sectors. In particulate control, equipment suppliers have generally had to cover a broad range of manufacturing customers, industrial processes, and geographic regions. Those suppliers enjoying established positions in this market have generally been successful by focusing on certain industries and not diluting their sales efforts. Likewise, gaseous equipment suppliers have focused almost entirely on the electric utility industry, and those companies with historic relationships with utility customers are likely to maintain the best market positions.

APC equipment suppliers are more frequently involved in the construction of the APC systems than their WPC equipment counterparts. The consulting engineering firm is less prominent with the APC vendor as the source of design and engineering services. As a result, APC equipment suppliers enjoy markets which are a greater percentage of the total investment. We estimate that for every dollar realized in flange-to-flange equipment shipments, an additional one to two dollars is available for technical services and supplier installation to the APC equipment supplier.

4.2.2 Specialty Equipment

Table 4-13 summarizes the estimated APC investment required to meet existing Federal standards between now and 1986. This data is based on a preliminary draft of the 1977 Cost of Clean Air, and the estimates are expressed in millions of 1978 dollars.* Approximately $42.8 billion will be required to meet existing APC regulations, much of which is accounted for by existing plants. (Yet, equipment suppliers continue to report that recent APC shipments have been new-source oriented.) Of the industrial sectors, the energy industries collectively account for about half of the total investment required. This is due mainly to requirements for FGD systems.

Industrial backlog is heavily oriented toward new plant construction. Major markets for these will be the metals industry (most specifically iron and steel), the fuel industries, forest products and agricultural, and solid waste disposal--perhaps a "forgotten market" for particulate control.

The backup estimates for Table 4-13 unfortunately house some discrepancies. Perhaps the most puzzling one is found in the energy industries where no investment is shown in the EPA report for new plant construction over the coming eight-year period.

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*See Appendix for a more detailed industry-by-industry breakdown and a description of the control technologies used in the analysis.

TABLE 4-13

SUMMARY OF ESTIMATED AIR POLLUTION CONTROL INVESTMENT REQUIRED TO MEET EXISTING FEDERAL STANDARDS, 1977-1986

(millions of 1978 dollars)

Industry	Total Requirements 1970-1986	Investment Remaining 1977-1986
Energy Industries	34,910	21,440
Fuel Industries	7,140	4,100
Metal Industries	22,990	8,950
Chemical Manufacturing Industries	1,340	490
Quarrying and Construction Industry	710	150
Other Manufacturing Services	280	50
Forest Products & Agriculture	9,110	3,640
Solid Waste Disposal & Reduction	7,080	3,960
TOTAL	83,560	42,780

Source: Preliminary Draft of the 1977 Cost of Clean Air, Environmental Protection Agency.

Table 4-14 shows our estimates of the annual investment for air pollution control broken down by type of equipment. Note that of the particulate control devices listed, the electrostatic precipitator--in the 1977 "deadline" year--maintained its market dominance. There has been considerable interest regarding high temperature fabric filters as a substitute for electrostatics in the utility industry and fabric filters are expected to maintain or increase their current market position. The utility industry is most interested in furthering developments in this area, and as a result, could sustain an attractive market for the more efficient baghouses while electrostatics and other types of particulate control equipment lose ground. Mechanical collectors and scrubbers used for particulate control will remain only a small part of the market.

Regarding FGD systems, estimated 1977 expenditures were on the order of \$300 million--only about 20% of which was for flange-to-flange equipment. Most of the FGD market is for SO_2 control, with combination particulate/FGD systems being only a minor segment. The outlook for FGD systems is increasingly optimistic as new source power plants come onstream, local regulations tighten on industrial plants, and more flue gas standards are promulgated.

Positive factors affecting future APC equipment market growth will include: (1) the gradual transition of state and Federal environmental regulatory authorities from a standards-setting mode to an enforcement mode; (2) a shift in the base of the equipment market from existing, more reluctant sources to new facilities; (3) the possibility of adoption of more stringent particulate standards; and pending decisions on SO_x emission standards for both high and low sulfur coal.

There are several negative influences on future market size. Litigation filed both by industry and by regulatory authorities will probably be resolved only after extended legal action. Periodic challenges to the existing regulations will also tend to delay growth of other gaseous APC equipment markets, but will not defer investment indefinitely. Gaseous and particulate equipment shipments to the electric utility industry may also decline as planned new plant expansion is deferred by individual companies and as retrofit applications become exhausted. Nevertheless, forecasted growth rates for air pollution control equipment will be greater than GNP in general, and FGD market growth will be among the highest in the pollution control industry.

We estimate an overall growth for particulate control equipment of between 8 and 10% with the major fall-off taking place in the utility electrostatic market. The big uncertainty is the size of the remaining retrofit market in the manufacturing industries and the timing of enforcement for those sources. Of the estimates shown in Table 4-14, the 10-12% growth rate shown for fabric filters is perhaps the most volatile with key demand-dependent decisions still pending and major studies being made that will impact air-to-cloth ratios and baglife for utility applications.

Tables 4-15 and 4-16 list suppliers of particulate and FGD control systems, respectively.

TABLE 4-14

ESTIMATED 1977 AIR POLLUTION CONTROL EQUIPMENT SHIPMENTS AND ASSOCIATED INSTALLATION AND GROWTH THROUGH 1983

	1977 Annual Shipments ($ millions)	Growth 1977-1983 (%/yr)
Particulate Control Equipment[a]		
Electrostatic Precipitators	350	8-10
Fabric Filters	210	10-12
Mechanical Collectors	30	6-8
Scrubbers	50	10-12
Subtotal	640	8-10
Associated Installation[b]	1,020	-
Total	1,660	8-10
Gaseous Control Systems	300	16-18
GRAND TOTAL	1,960	9-12

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[a] Flange-to-flange equipment only.

[b] Includes erection, insulation materials, equipment transportation, liquid treatment systems for scrubbers, fans, ductwork, and other auxiliary equipment. Assumes installation costs as follows: precipitators, 150% of equipment cost; fabric filters, 150% mechanical collectors, 100%; and scrubbers, 300%.

Source: Arthur D. Little, Inc., estimates based on discussions with industry contacts.

TABLE 4-15

PARTICULATE CONTROL SYSTEM SUPPLIERS

	Electrostatic Precipitators	Fabric Filters
Major Suppliers		
American Air Filter	X	X
Envirotech (Buell)	X	X
Joy Manufacturing	X	X
Research-Cottrell	X	X
U. S. Filter		X
Wheelabrator-Frye	X	X
Other Suppliers		
Dresser Industries	X	X
Carborundum		X
Combustion Engineering	X	X
Combustion Equipment Associates		X
Koppers	X	X
Peabody International	X	X
UOP	X	X

TABLE 4-16

SO_x CONTROL SYSTEM SUPPLIERS

	Non-Recovery	Recovery
Major Suppliers		
Babcock & Wilcox	X	
Combustion Engineering	X	
Combustion Equipment Associates	X	
Envirotech (Chemico)	X	X
Research-Cottrell	X	
UOP	X	X
Other Suppliers		
American Air Filter	X	
Davy Powergas		X
FMC	X	
Peabody International	X	
Pullman Kellogg	X	
Riley Stoker/Environeering	X	
Wheelabrator-Frye/A. I.	X	

4.2.3 APC Instrumentation

Like the WPC instrumentation market, air pollution control instrumentation here includes both monitors and controllers as well as analyzers. There are limited opportunities for sophisticated computer-oriented automation systems other than automatic alarm systems.

The regulatory driving forces are those air pollution control statutes previously mentioned. APC instrumentation suppliers are commonly beset by uncertainty centered around such issues as the types of levels of gas that are to be monitored and the varying enforcement policies of state regulatory authorities. Some improvements in the market environment have been made with the aid of such agencies as OSHA with its interest in toxic substances such as vinyl chloride. Also, over the next few years, there should be an increased emphasis in NO_x monitoring, especially by utility customers.

Perhaps more so than any of the other sectors, where there is no enforcement by regulations, there is essentially no market for APC instrumentation. Regionally, the West Coast (i.e., California) is the most diligent in its APC enforcement, followed by New York and Illinois. Similarly, utilities are more inclined to purchase monitoring equipment because they themselves are constantly being monitored by a variety of government agencies.

The APC instrumentation market can generally be divided into a stationary source market and an ambient air market. Stationary source monitoring is estimated to total $10 million annually, about half of which is equipment, and is expected to grow about 10% per year in real terms over the next few years. The market is divided in the following way:

Industrial Customers		80%
Utilities	50%	
Industry	30%	
Government Customers (mostly Federal)		20%
		100%

The ambient air market totaled approximately $30-$40 million in 1977, again about half of which is equipment. Of this, approximately 80% is government-related while the remaining 20% is purchased by major corporations. The ambient market has historically grown at a slower pace (3-5% per year) than the stationary source segment.

We estimate that the growth outlook for stationary source monitoring instrumentation will fall within the range of 10-12% annually, depending upon the trend within key state regulatory agencies. The market for ambient air instrumentation should maintain a lower (6-8%) annual growth rate--slightly higher than its past performance because of anticipated increasing Federal pressures on state agencies to implement their state implementation plans (SIP's).

Suppliers of APC instrumentation are shown in Table 4-17. Beckman Instruments is recognized as the market leader.

4.3 RESOURCE RECOVERY

The focus of this study upon solid waste management was limited to the recovery of resources (energy and materials) from municipal solid waste streams. This market opportunity translates into a new, embryonic business associated with the construction of resource recovery facilities. Our scope did not include, therefore, the bulk of expenditures related to solid waste management. These excluded businesses are the collection, the transportation, and the disposal of municipal solid waste (MSW) through traditional sanitary landfills or open dumps.

4.3.1 The Business Environment

The driving forces for solid waste management have been less direct than those for water pollution control and air pollution control. Unlike water and air pollution, society has been less able to defer expenditures on solid waste handling. The physical impediments, social discomforts, and health risks associated with unmanaged solid waste have long necessitated its management.

In recent years, solid waste has often been termed the "third pollution" in terms of regulatory and social priorities. This partly relates to the fact that there has been less of a "catch-up" problem than in water and air pollution.

As this business is less of a legislated market and more one of necessity, some of the participants find it more attractive than the other pollution control businesses. Suppliers feel that their competitive fortunes are in this way more within their control.

On the other hand, this young business has been no less frustrating and is already sufficiently populated with willing competitors. The current "demonstration" market is not big enough to meet the anticipated sales goals of all these competitors. Many of these are large corporations--on average, larger than the traditional suppliers of air and water pollution control products.

TABLE 4-17

AIR POLLUTION CONTROL INSTRUMENTATION SUPPLIERS

Beckman Instruments

Monitor Labs

Bendix

MDA Scientific

Lear Siegler

Environmental Data Corporation

Tyco

Meloy Laboratories

4.3.1.1 Marketing Requirements

The marketing requirements for a successful resource recovery business are greater than any others in the PCI and may rival any to be found in the U. S. economy.

Individual towns must be sold on this new approach to solid waste management. Existing disposal operations (whether municipal or private) must be taken into account if the new approach is to be accepted. Regionalization has presented a greater opportunity for resource recovery systems, but regionalization has also complicated marketing requirements. Selling a regional plant means that a number of municipalities must be sold and that they must agree on the approach, the site, and the financial arrangements. EPA and other regulatory bodies are also part of the marketing environment.

An important characteristic of the resource recovery business is that it is two businesses: a trash disposal business on the one hand and a resource recovery business on the other. Its glamor side is the recovery of material and energy values from these waste streams. The other side of reality is that it is still a trash and garbage business. After the recovery of materials and energy has taken place, there remains a significant residual for final disposal. Hence, all resource recovery facilities have associated landfilling operations.

The existence of two businesses--the trash side and the resource recovery side--adds to the marketing complexities of the business. On the resource recovery side, users of the energy and of the recovered material must be found within practical distances. As many of these markets for materials are scrap markets, the business must also be able to tolerate the wide swings and the prices which these materials can demand.

4.3.1.2 Regulatory Driving Forces

The Resource Conservation and Recovery Act (RCRA) of 1976 is the most recent solid waste legislation. When implemented, it will increase the regulation and management of landfills, increase the cost of landfill practices, and thereby create opportunities for resource recovery systems to be competitive.

Energy and resource conservation legislation is the other important source of demand for resource recovery systems. Municipal solid waste represents a significant, though not large, source of supplemental energy for a locality, a region, or an industrial facility. A return to coal utilization in this country will also provide more opportunities for combined combustion of coal and refuse derived fuels.

The Clean Drinking Water Act, the Ocean Dumping Act, the Clean Air Act, and the Wetlands Act will also play minor roles in the development of resource recovery opportunities. The Clean Drinking Water Act and the

Wetlands Act will also play minor roles in the development of resource recovery opportunities. The Clean Drinking Water Act and the Wetlands Act will constrain landfill practices and the availability of new landfill sites. By 1981, the Ocean Dumping Act will prescribe further disposal of sewage sludges by seacoast cities. Resource recovery systems offer a disposal alternative for these cities via co-disposal of these sludges with solid waste. The Clean Air Act has already worked to close down most of the traditional incinerators in the country. The only kind of legislation that could work against centralized resource recovery (through its economics) is that of source segregation.

4.3.2 Leading Technologies

4.3.2.1 Energy Recovery

Currently, there are three leading contenders for resource recovery applications: waterwall incineration, refuse derived fuels (RDF), and pyrolysis. Other technologies are not likely to be important in this business in the next decade and were generally excluded from our demand analysis.

Waterwall incineration is the leading resource recovery technology in this demonstration market. The technology was first practiced in Europe and has gained acceptance in the United States. Installations currently exist in Saugus, Massachusetts; Harrisburg, Pennsylvania; Chicago, Illinois; and Nashville, Tennessee. The technology is generally considered proven in Europe. The main product of a waterwall incineration system is steam for use by an industrial or utility user.

RDF can be produced from municipal solid waste in several forms: shredded, powdered, or densified. These can be transported to an industrial or utility user as a supplemental fuel for its boilers. The RDF approach is potentially competitive on a general basis with waterwall incineration, but the technology is still being proven. Hence, the future for this technology revolves around its being proven in the next two to four years. If it doesn't achieve anticipated performance and economics, waterwall incineration will have the market largely to itself over the next decade. If RDF is proven, it may compete head-to-head with waterwall incineration in the near- and intermediate-term.

Although pyrolysis continues to receive its share of attention, the PCI has come to discount the near-term role of pyrolysis in resource recovery from that which was envisioned only a few years ago. Our estimates of the market shares expected for pyrolysis are lower than we would have estimated a few years ago.

Commercial attempts to install and successfully operate large-scale pyrolysis systems in this country have uncovered still serious limitations and problems. The experience in Baltimore has been the biggest disappointment to date. At this point in time, it is still expected that these problems will be solved, but that it isn't likely to happen very soon. Pyrolysis remains attractive in a technical sense and is the system most compatible with co-disposal of sewage sludges. Its energy product--a gas--has the highest form value.

4.3.2.2 Materials Recovery

The recovery of ferrous materials through magnetic separation processes is a proven resource recovery technology. It is presently practiced in more than 30 communities in the United States. The recovered material may be used in iron and steelmaking, iron foundries, copper mining, and detinning operations.

The next most widely practiced materials recovery systems are targeted at aluminum. The economics are usually not as good as those for ferrous metals recovery because of the relatively small amount of aluminum in the municipal waste stream. Recovered aluminum can be used for the manufacture of sheet stock for aluminum cans.

The recovery of glass from municipal solid waste is still in the development phases. More than a half dozen systems for glass recovery are presently on the drawing boards. Recovered glass will likely be used for container manufacture or in construction products. The control and separation of different colored glass has to be controlled carefully if it's to be used in container manufacture. As with ferrous and aluminum materials, the availability of a nearby market for glass materials is an important factor in the economics of glass recovery.

Technologies for the recovery of paper fiber from municipal solid waste are still in thinking stages. To date, the Black Clawson process to recover paper fiber is now directed to energy recovery and not to fiber recovery per se.

4.3.3 Potential Markets

The market estimates provided in this section are lower than might have been forecasted a few years ago. It is not uncommon to find forecasts which are a factor of two larger than these. Similarly, the installed capacity of resource recovery systems today is short of what was expected by earlier analysts.

Resource recovery is an embryonic market. It is still a demonstration market. Each resource recovery system built (even by one supplier) is different from the previous one. The driving forces are there, but the marketing requirements are severe, and it takes a long time for municipalities to make decisions. This is particularly true when it involves a new way of handling solid waste and, more importantly, when it involves doing it jointly with other communities. Large-scale resource recovery systems are generally considered economic only if they can command daily tonnages of 500-1,000 tons per day (TPD). That corresponds to populations of several hundred thousand people (at 3.5 lbs. per day per capita).

Table 4-18 lists the current resource recovery projects which are operational or under construction. Of the 21 projects, five were originally intended as demonstration plants. Three of those were successfully demonstrated (St. Louis, Missouri; Franklin, Ohio; and South Charleston, West Virginia). One is currently in its shakedown stages (San Diego County) and one is still under construction. Two of the commercial-size plants are still in shakedown stages, and another plant (Baltimore) had serious problems which caused the original supplier to abandon the project. In summary, most of these plants have yet to establish a record of reliability or profitability (where privately operated).

These projects have been starting up at the pace of about two to four per year since the early to mid-1970's. The projects listed in Table 4-18 will account for about 17,500 TPD capacity when operational.

Waterwall incinerators are used in seven of these projects and account for 8.5 thousand TPD of capacity (or nearly half of the total). RDF systems are being tried in nine of these facilities and amount to 7.7 thousand TPD or about 45% of the total. In addition to the 21 facilities under construction or operational, another 21 projects are currently in their planning stages. The capacity of the planned 21 projects is double that of the 21 projects in Table 4-18. Only two of the planned projects are pyrolysis units; the remainder are split fairly evenly between waterwall incinerators and RDF facilities.

Our market projections are presented in Table 4-19. At the present time, the annual market is estimated to be about $100 MM. The projected number of new facilities is estimated at three to five projects per year between 1978 and 1982--or between $150-$300 MM (exclusive of operating fees) in total facility costs. In the period 1983-1987, the pace of activity should increase to a level of four to seven units per year--or $200-$400 MM per year.

In terms of technology, we expect (assuming that RDF approaches are proven) that the market will be split fairly evenly between waterwall incinerators and RDF facilities with the latter gaining in market share in the 1983-1987 period.

TABLE 4-18

RESOURCE RECOVERY ACTIVITIES IN THE UNITED STATES
(as of July 1977)

				ENERGY FORM				MATERIALS			
Yr	Location	Capacity TPD	Status	Steam	Solid	Gas	Liquid	Ferrous	Aluminum	Glass	Fiber
78	Akron, OH	1,000	Construction	X							
75	Ames, IA	200	Operational		X			X	X		
75	Baltimore, MD	1,000	Operational	X				X			
76	Baltimore County	600	Operational		X			X	X[a]	X[a]	
78	Bridgeport, CT	1,500	Construction		X			X	X	X	
76	Bridgewater, MA	600	Shakedown		X			X			
77	Chicago, IL	1,000	Operational		X			X			
70	Chicago, IL	1,600	Operational	X				X			
71	Franklin, OH[b]	150	Operational					X	X	X	X[c]
72	Harrisburg, PA	1,000	Operational	X				X			
78	Hempstead, NY	2,000	Construction	X				X	X	X	
79	Lane County, OR	500	Construction		X			X			
77	Milwaukee, WI	1,000	Shakedown		X			X	X		
79	Monroe County, NY	2,000	Construction		X			X	X	X	
74	Nashville, TN	720	Operational	X							
76	New Orleans, LA	650	Operational					X	X[a]	X[a]	
79	Pompano Beach, FL	50	Construction			X		X			
77	San Diego County	200	Shakedown				X	X	X	X	
76	Saugus, MA	1,200	Operational	X				X			
74	S. Charleston, WV	200	Operational			X		X			
72	St. Louis, MO[b]	300	Operational		X			X			

[a] Operational in late 1977.

[b] Demonstration plant - 50 TPD being processed.

[c] Converting to RDF.

Source: Arthur D. Little, Inc.

TABLE 4-19

MARKETS FOR RESOURCE RECOVERY FACILITIES

Trend By Capacity

Year	Projects Per Year	Daily Tonnage Per Year	Annual Sales Value (1977 dollars)
1978-1982	3-5	5,000-7,000	$150-300 MM
1983-1987	4-7	6,000-9,000	$200-400 MM

Source: Arthur D. Little, Inc.

4.4 GENERAL ISSUES

4.4.1 Growth Potential Remains

There is still attractive growth ahead in most pollution control markets. As in the past, delays in statutory and regulatory deadlines will translate into market delays. While overall growth rates over the next decade can be expected to outstrip that of the GNP (nearly double that pace), the rate of market growth may have crested somewhere in the 1975-1977 period.

The end of the retrofit market has always appeared to be just over the horizon. Clearly, the retrofit market is now declining as most of that job seems to have been done. The retrofitting of air pollution control requirements on utilities is largely done except for isolated markets such as TVA, American Electric Power, and coal reconversion units. The amount of retrofit still to be done on industrial facilities for air pollution control is much less clear.

A larger retrofit market remains in wastewater treatment, mostly in the municipal sector where the Nation is still reaching for secondary treatment. A significant BAT retrofit market may still exist for industrial wastewater treatment, but much of that may not be seen until permits are rewritten or until best available technologies are installed.

In wastewater treatment (and possibly also in air pollution control), a larger proportion of the retrofit market remains associated with smaller industrial facilities. The markets associated with retrofitting smaller industrial facilities present more difficult marketing challenges and may be more price competitive.

4.4.2 Business Cyclicality

There can be no question that pollution control businesses have had their cycles, although those cycles have not necessarily corresponded to the general business cycle. As these legislated markets have been tied to catching up with pollution problems, the PCI has been, to some degree, recession resistant. Dependence upon the capital investment cycle will increase as the business becomes associated more with new source construction and less with retrofit activity.

The business has experienced a plateau of dip in most of its sectors in the last two years. These plateaus are partly related to regulatory deadlines. In the municipal wastewater treatment sector, demand plateaus have been periodically caused by impoundments of Federal funds. While the threat of further impounding is thought to be a problem of the past, not all suppliers feel confident that there will be a continued stream of municipal treatment activity.

4.4.3 Some Cloudy Areas of the Crystal Ball

The history of the pollution control business teaches that there have been many anticipated markets which have not materialized--what we call "ghost markets." There is the possibility that future anticipated markets will meet the same fate. Other markets will face substantial delays because of difficulties related to regulatory implementation or the lack of appropriate technologies.

The industrial market for pollution control equipment and products is generally cloudy to forecast. The market is very horizontal, involving every SIC sector of the U. S. economy. It is extremely difficult, if not impossible, for a pollution control supplier either to understand or to serve the breadth of the market just as it is for EPA to document and move evenly towards addressing the problems of each industrial sector.

It is not at all clear that a market for pollution control systems will derive from the implementation of the Toxic Substances and Control Act. It is not clear how soon it will materialize and how much of the total problem will be solved through pollution control approaches.

It will be equally difficult to anticipate the impacts of the Clean Drinking Water Act upon the water pollution control business. The problem of combined sewers is still in the background; its real potential and size are uncertain. The expected market for tertiary treatment or advanced treatment technologies in both municipal and industrial situations is now in doubt; reports by both EPA and the National Commission on Water Quality have questioned either their priority or their cost-effectiveness in the municipal and industrial sectors.

In air pollution control, regulatory concepts and initiatives such as the prevention of significant deterioration, trade-off schemes for cleaning up non-attainment areas, and the completion of state implementation plans are almost impossible to translate into tangible market opportunities. These kinds of regulations are implemented on a site-by-site basis and may not involve the consistent use of technology across similar situations. Hence, it will be difficult to estimate the potential associated with these kinds of initiatives until they are almost upon the industry.

In air pollution control, the timing and extent of regulating further gaseous pollutants from stationary sources are not clear. These include regulations for NO_x, hydrocarbons, and hazardous emissions.

There is a large potential air pollution control business associated with the reconversion of power plants to coal. Yet, realistic observers question how much pollution control will actually be forced upon the older facilities.

We have also not addressed the kinds of businesses which may be created as a result of increased attention to operating and maintenance of pollution control facilities. It is possible that a whole new industry may arise to service the needs of municipal, utility, and industrial customers on an ongoing basis. This could include monitoring, analytical services, consulting services, and operating materials. The potential is there, but the market (i.e., the need) has not arrived.

A final limitation is that not much market research is done by the suppliers themselves. As the industry feels it cannot afford to do technical R&D, it also does not comfortably spend monies on internal market research. Hence, the major sources of information are government sources, e.g., EPA, the Council on Environmental Quality, and the Department of Commerce. The problem with such market research materials is that government surveys and analyses are usually done for other purposes. Surveys may only cover certain industries and, therefore, be incomplete. They may assume compliance by a certain date when history teaches that compliance dates tend to drag out. When surveys ask for estimates on spending, respondents are not consistent in what is included as pollution control expenditures. All this adds to the uncertainty of the pollution control industry.

4.4.4 Employment Associated with Pollution Control Industry Demand

From an analysis of employment statistics for the companies participating in the PCI, the average amount of sales per employee was found to be about $50,000 in 1976.* The companies used for this calculation were the same as those used in the financial analyses later in this report. Given the estimated levels of demand in 1977 for the major PCI sectors, the associated annual job equivalents in the PCI are estimated to be over 35,000. This determination is summarized in Table 4-20.

The job equivalents associated with each sector of demand were determined by using average sales/employee ratios for that sector and the level of demand (rounded) estimated earlier in this section of the report. The level of demand associated with the six pollution control product sectors totaled $1,750 million in 1977. Companies in the WPC equipment, APC equipment, and resource recovery sectors all averaged around $50,000 per employee. The sales-per-employee ratio was somewhat less for instrumentation companies ($40,000 per employee) and somewhat more for WPC chemicals ($65,000 per employee).**

These employment estimates cover only the jobs in these companies associated with specialty equipment. They do not include the jobs associated with the design and construction of such facilities--tasks often performed by other firms or contractors but which may be done by these same companies.

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[*] A FORTUNE analysis of 1976 figures for "all industries" indicated an average of $56,000 per employee. (FORTUNE, May 1977, p. 389.)

[**] FORTUNE averages for "metal products" were $47,000 per employee; for "measuring equipment" were $36,000 per employee; and for "chemicals" were $68,000 per employee. (Ibid.)

TABLE 4-20

ESTIMATED NUMBER OF JOBS ASSOCIATED WITH THE SUPPLY OF POLLUTION CONTROL PRODUCTS

(Current and Projected)

Major PCI Sectors	Approx. Level of 1977 Demand (MM$/yr)	Current (1977) Average Sales/Employee (M$/Employee)	Associated Annual Job Equivalents-1977
WPC Equipment	550	50	11,000
WPC Instrumentation	150	40	3,750
WPC Chemicals	250	65	3,850
APC Equipment	700	50	14,000
APC Instrumentation	50	40	1,250
Resource Recovery	100	50	2,000
TOTAL (Average)	$1,800	$50	35,850

	Projected Level of 1983 Demand (MM$/yr)	Projected (1983) Average Sales/Employee (M$/Employee)	Projected Associated Annual Job Equivalents-1983
WPC Equipment	1,000	80	12,500
WPC Instrumentation	300	60	5,000
WPC Chemicals	600	100	6,000
APC Equipment	1,250	80	15,600
APC Instrumentation	100	60	1,700
Resource Recovery	250	80	3,100
TOTAL (Average)	$3,500	$80	43,900

This range (Table 4-20) of average sales-per-employee ratios ($40-$65,000 per employee) for the PCI has increased substantially from $30-$35,000 per employee in 1972.* To the extent that this ratio has continued to increase, our use of 1976 averages for these 1977 estimates may overstate somewhat the employment figures in Table 4-20. This represents about a 10% increase per year over a period in which sales for these companies increased at 15-20% per year. A large part of this increase in the sales-per-employee ratio has been in part due to inflation. It may also represent a significant trend towards the outside fabrication of equipment systems by PCI companies. Other possible causes include increased productivity or cost-motivated controls on staffing. The latter is possible because 1973-75 were years of severe fixed-price contract problems in the PCI.

We have projected employment in the PCI for 1983 based on our projections of market growth in each sector and a further increase in the sales-per-employee ratio. We have assumed that the sales-per-employee ratio will increase proportionately the same in 1977-1983 and it has in 1972-1977. Hence, the PCI is projected to have an average sales-per-employee ratio of $80,000 in 1983 (versus $50,000 in 1977).

Estimated jobs in the PCI in 1983 are projected to total (Table 4-21) $43,900, an increase of about 8,000 jobs in the six-year period. Corresponding to that increase is an overall growth rate for the PCI of 11.5% per year. Based on recent experience, inflation and other factors will boost the sales-per-employee ratio at 8.0% per year. As a result, employment is projected to grow at 3.5% per year during this period.

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*Economic Impact Study of the Pollution Abatement Equipment Industry, Report to EPA by Arthur D. Little, Inc., December 1972.

In the FORTUNE analyses, the ratio for "metal products" similarly increased from $29,000 per employee in 1972 to $47,000 per employee in 1976. (FORTUNE, May 1973, p. 245.)

5.0 FINANCIAL PERFORMANCE OF THE POLLUTION CONTROL INDUSTRY

5.1 INTRODUCTION AND SUMMARY

5.1.1 Definitions

Selected companies participating in the PCI were aggregated to provide representative financial data. Aggregations were made for the businesses of air pollution equipment, instrumentation systems, water pollution equipment, resource recovery systems, and water treatment chemicals. Groups were then disaggregated on the basis of estimated overall corporate involvement in pollution control, e.g., more than 10% and less than 10% (or in the use of solid wastes, greater than 50%) of corporate sales generated from all pollution control businesses. Only the ">10%" groupings were used as the basis for representative financial data averages. The groupings are not mutually exclusive as many companies are involved in several pollution control markets.

Pollution control industry groups were developed in five major categories:

- APC Equipment Manufacturers (APC Equipment)
- APC and WPC Instrumentation Companies (APC/WPC Inst.)
- WPC Equipment Manufacturers (WPC Equipment)
- Water Treatment Chemical Manufacturers (WT Chem)
- Solid Waste Management Systems Companies (SWM Systems)

The lists of companies that comprise the eleven composites are shown in Appendices 5-1 through 5-5. Financial data for each of the companies were collected for five years--1972 through 1976--from corporate annual reports, SEC Forms 10-K, Moody's Industrial Manuals, and Standard and Poors' Industry Surveys.

As a yardstick for comparison, comparative data were developed on companies involved in three similar but broader industries: Chemical Manufacturing, Instrumentation Manufacturing, and Industrial Machinery Manufacturing. The individual companies that comprised each of the three comparative composites are shown in Appendix 5-6. The source of these comparative composites was the Federal Trade Commission's Quarterly Financial Reports for Manufacturing Corporations. Comparative information for "All Manufacturing" was also taken from the Federal Trade Commission's Quarterly Financial Reports.

5.1.2 Financial Performance Measures

Profitability and other financial ratios were calculated for all groups, including: Return on Investment, Return on Assets, Return on Sales, Return on Equity, and Debt to Total Capital. In addition to these ratios, average annual growth in sales, After Tax Income, Total Assets, divisional sales, and Pretax Income (where available) was calculated. Following is a brief explanation of how each ratio was computed:

Return on Equity: After Tax Corporate Income as the return on total Stockholders' Equity--both preferred and common shareholders' equity:

$$\frac{\text{After Tax Income}}{\text{Stockholders' Equity}} = \text{ROE}$$

Return on Assets: After Tax Corporate Income as the return on Total Assets:

$$\frac{\text{After Tax Income}}{\text{Total Assets}} = \text{ROA}$$

Return on Sales: After Tax Corporate Income as the return on Total Sales:

$$\frac{\text{After Tax Income}}{\text{Total Sales}} = \text{ROS}$$

Return on Investment: (or Return on Capital Employed) This ratio was computed by adding After Tax Income and Pretax Net Interest and dividing the sum by Capital Employed, which is defined as the difference between Total Assets and Current Liabilities:

$$\frac{\text{After Tax Income plus Pretax Net Interest}}{\text{Total Assets less Current Liabilities}} = \text{ROI}$$

This ratio corrects for the interest payments which may distort a firm's true returns.

Long Term Debt to Total Capital: Long Term Debt as a percent of Total Capital, i.e., Long Term Debt plus Stockholders' Equity:

$$\frac{\text{Long Term Debt}}{\text{Long Term Debt plus Stockholders' Equity}} = \text{Debt Ratio}$$

5.1.3 Summary of Overall Performance

Tables 5-1(A) and 5-1(B) summarize the performance of the PCI groups and comparative industry composites in terms of Sales Growth, Net Income Growth, Average Debt Ratio, Average Return on Equity, and Return on Sales.

The average annual sales growth (calculated in current dollars) between 1972 and 1976 for all the PCI composites was stronger than the 9.0% per year growth for All Manufacturing. However, the sales growths for the PCI groups were not dissimilar from those of their broader industry composites--i.e., all were within range of 16-18% per year.

Among the PCI composites, the WT Chem companies had the highest annual sales growth at 22% per year. APC equipment companies were next, growing at 20% per year. Average annual growth of net income after tax for all PCI composites was ahead of, or on a par with, All Manufacturing which showed a 15% per year growth. The APC/WPC Instrumentation companies and the APC equipment companies had the highest annual growth in net income--25% and 23%, respectively.

The PCI group that outperformed all other PCI groups and comparative industry composites was the WT Chem companies. This group was the least leveraged with an Average Debt Ratio of 13%, had the highest average ROE at 15%, and the highest average ROS at 7%. In every case, the sales growth of the PCI groups outperformed GNP which grew at 9.6% per year in current dollars from 1972-1976.

5.2 AIR POLLUTION CONTROL EQUIPMENT

Average annual sales growth for the APC Equipment companies exceeded that of the Industrial Machinery and the All Manufacturing composites. Corporate sales grew at 19.8% compounded annually from 1972-1976 for the APC group, compared to 17.7% for Industrial Machinery and 9.1% for All Manufacturing. Sales for the divisions in these companies which housed their APC activities grew at a somewhat faster rate than overall corporate sales, 22.1% versus 19.8%.

When financial performance is measured either by ROA, ROE, ROI, or ROS, the Industrial Machinery composite outperformed the APC group, as shown in Table 5-2. ROI for this group averaged 9.5% for 1972-1976, compared with an average of 10.6% for the Industrial Machinery composite. Debt to Total Capital for the APC Equipment companies and the comparative Industrial Machinery composite averaged 26% and 23%, respectively.

Overall, this sector of the PCI has experienced generally higher growth in Sales, growth in After Tax Income, and growth in Assets than the other sectors of the PCI, and has kept pace in terms of profitability.

The leading companies in this sector range in size from $100 MM to $700 MM in annual corporate sales (Appendix 5-1). The billion-dollar participants are not volume leaders in air pollution control equipment, although Combustion Engineering and Babcock & Wilcox are among the top six suppliers in the newer markets for FGD systems.

TABLE 5-1(A)

AVERAGE ANNUAL GROWTH IN SALES AND NET INCOME AND AVERAGE DEBT RATIOS FOR POLLUTION CONTROL INDUSTRY GROUPS AND COMPARATIVE INDUSTRY COMPOSITES

PCI Composites:	Sales Growth 1972-1976 (%/yr)	After Tax Income Growth 1972-1976 (%/yr)	Average Debt Ratio 1972-1976 (%)
APC/WPC Inst.	16	25	25
APC Equip.	20	23	26
WPC Equip.	18	19	18
SWM Systems	18	13	32
Wt Chem	22	20	13
Comparative Industry Composites:			
All Manufacturing	9	15	--
Industrial Machinery	18	11	23
Industrial Chemicals	17	18	30
Instrumentation	16	25	25

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poors' Industry Survey.

TABLE 5-1(B)

AVERAGE ROE AND ROS FOR 1976 AND FOR THE PERIOD 1972-1976 FOR PCI GROUPS AND COMPARATIVE INDUSTRY COMPOSITES

PCI Composites:	ROE-1976 (%)	Average ROE 1972-1976 (%)	ROS-1976 (%)	Average ROS 1972-1976 (%)
APC/WPC Inst.	13.0	11	6.1	5
APC Equip.	12.8	10	4.6	4
WPC Equip.	13.1	11	4.6	4
SWM Systems	11.7	11	4.4	5
Wt Chem	17.8	15	7.3	7
Comparative Industry Composites:				
All Manufacturing	13.9	13	5.4	5
Industrial Machinery	12.6	14	5.1	6
Industrial Chemicals	14.4	14	6.7	7
Instrumentation	12.8	10	4.7	4

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poors' Industry Survey.

TABLE 5-2

AIR POLLUTION CONTROL EQUIPMENT MANUFACTURERS

Average Annual Growth 1972-1976:	APC Equipment Group	Industrial Machinery Composite	All Manufacturing
Corporate Sales:	19.8%	17.7%	9.1%
Corporate After Tax Income:	23.3%	10.8%	15.3%
Corporate Assets:	16.1%	15.9%	--
Divisional Sales:	22.1%	--	--

	1972	1973	1974	1975	1976	Average 1972-1976
Return on Assets %:						
APC Equip.	4.9	5.3	4.1	5.3	6.2	5.2
Industrial Machinery	8.0	8.5	7.6	7.4	6.7	7.7
Return on Equity %:						
APC Equip.	8.6	9.4	9.0	11.2	12.8	10.2
Industrial Machinery	13.1	15.3	14.9	14.1	12.6	14.0
Return on Investment %:						
APC Equip.	7.5	8.4	8.9	11.1	11.7	9.5
Industrial Machinery	10.0	11.2	11.0	10.8	9.8	10.6
Return on Sales %:						
APC Equip.	4.1	4.1	3.3	4.0	4.6	4.0
Industrial Machinery	6.5	6.5	5.8	5.7	5.1	5.9
Debt to Capital %:						
APC Equip.	26	31	29	25	21	26
Industrial Machinery	19	20	26	26	25	23

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poors' Industry Survey.

5.3 AIR & WATER POLLUTION CONTROL INSTRUMENTATION

The financial performance of the companies involved in pollution control instrumentation compared favorably to those included in the composite representing the broader instrumentation business.

As shown in Table 5-3, the APC/WPC Instrumentation companies had a higher rate of growth in Sales, After Tax Income, and Assets than did the broader Industry Composite. In both composites, After Tax Income increased faster than Sales Income which grew at a rate of 25.2% per year.

The APC/WPC Instrumentation companies outperformed the Instrumentation Composite in all measures of profitability. The greatest difference occurred in Return on Investment--11.0% on average for the APC/WPC Instrumentation companies, compared with 8.0% for the Instrumentation composite.

This group of companies had an average 25% Debt to Total Capital ratio for the five-year period similar to that of the other sectors of the PCI.

The leading companies supplying instrumentation for pollution control applications (Appendix 5-2) are primarily suppliers of process instrumentation. They range in size from $100 MM to $700 MM in annual corporate sales. Larger instrumentation companies are not major factors in pollution control.

5.4 WATER POLLUTION CONTROL EQUIPMENT

Sales of WPC Equipment companies (Table 5-4) grew at approximately the same rate as the Industrial Machinery composite. In After Tax Income, the WPC Equipment group grew at close to twice the rate of the comparative composite. Divisional sales growth of the WPC Equipment companies increased at a slightly higher rate than the overall corporate sales growth, 20.3% versus 18.2% per year. Corporate sales grew at twice the average annual rate of GNP--18.2% per year versus 9.6%.

WPC Equipment manufacturers did not perform as well in profitability as the comparative group. Return on Assets averaged 5.8% per year for the WPC Equipment companies versus 7.6% per year for the comparative composite. Return on Equity was marginally ahead of the comparative group in 1976, but the five-year average was 11.0% for WPC Equipment versus 14.0% for the comparative group. In general, 1974 was the worst year; 1975 and 1976 brought gradual improvement in terms of ROA, ROE, ROI, and ROS for WPC Equipment.

Average Return on Sales for WPC Equipment was well below that of the comparative group--4.1% versus 5.9%. ROI was about the same for both groups. The average Debt to Total Capital for the WPC Equipment companies was 18%--well below the 23% yearly average for the Industrial Machinery composite.

TABLE 5-3

AIR AND WATER POLLUTION CONTROL INSTRUMENTATION SUPPLIERS

Average Annual Growth 1972-1976:	APC/WPC Instrumentation	Instrumentation Composite	All Manufacturing
Corporate Sales:	15.9%	13.8%	9.1%
Corporate After Tax Income:	25.2%	22.5%	15.3%
Corporate Assets:	15.0%	11.9%	--
Divisional Sales:	16.9%	--	--

	1972	1973	1974	1975	1976	Average 1972-1976
Return on Assets %:						
APC/WPC Instrumentation	5.2	5.3	4.9	6.3	7.3	6.0
Instrumentation Composite	4.6	4.8	4.3	5.4	6.7	5.0
Return on Equity %:						
APC/WPC Instrumentation	8.4	9.2	9.9	11.8	13.0	10.5
Instrumentation Composite	8.3	9.2	9.1	10.6	12.8	10.0
Return on Investment %:						
APC/WPC Instrumentation	8.3	9.2	11.2	12.8	12.5	11.0
Instrumentation Composite	6.7	7.3	7.0	8.7	9.7	8.0
Return on Sales %:						
APC/WPC Instrumentation	4.5	4.8	4.6	5.3	6.1	5.0
Instrumentation Composite	3.5	3.7	3.7	3.8	4.7	4.0
Debt to Capital %:						
APC/WPC Instrumentation	22	27	28	23	26	25
Instrumentation Composite	22	24	30	26	25	25

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poors' Industry Survey.

TABLE 5-4

WATER POLLUTION CONTROL EQUIPMENT MANUFACTURERS

Average Annual Growth 1972-1976:	WPC Equipment Companies	Industrial Machinery Composite	All Manufacturing
Corporate Sales:	18.2%	17.7%	9.1%
Corporate After Tax Income:	18.9%	10.8%	15.3%
Corporate Assets:	14.2%	15.9%	--
Divisional Sales:	20.3%	--	--

Return on Assets %:	1972	1973	1974	1975	1976	Average 1972-1976
WPC Equip.	5.8	5.7	5.0	5.7	6.8	5.8
Industrial Machinery	8.0	8.5	7.6	7.4	6.7	7.6
Return on Equity %:						
WPC Equip.	10.0	10.3	10.0	11.4	13.1	11.0
Industrial Machinery	13.1	15.3	14.9	14.1	12.6	14.0
Return on Investment %:						
WPC Equip.	9.2	9.5	10.0	11.1	12.0	10.4
Industrial Machinery	10.0	11.2	11.0	10.8	9.8	10.6
Return on Sales %:						
WPC Equip.	4.5	4.1	3.4	3.9	4.6	4.1
Industrial Machinery	6.5	6.5	5.8	5.7	5.1	5.9
Debt to Capital %:						
WPC Equip.	14	18	20	23	17	18
Industrial Machinery	19	20	26	26	25	23

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poor's Industry Survey.

Most of the leading suppliers in WPC Equipment are in the size range of $100 MM to $700 MM in annual corporate sales (Appendix 5-3). Only FMC, among the billion-dollar companies, is among the volume leaders for this PCI sector.

5.5 WATER TREATMENT CHEMICALS

The Water Treatment Chemical group (WT Chem) outperformed the Industrial Chemicals composite on every measure of performance. The WT Chem group had the highest five-year average ROE (at 15.3%) and the highest ROS (at 7.2%) of any PCI sector or comparative industry composite.

The WT Chem group had an average ROA of 10.3% versus 7.3% (see Table 5-5) for the Industrial Chemicals composite. ROI for the WT Chem group averaged 14.5% versus 9.6% for the comparative group.

The WT Chem companies were the least leveraged of any of the PCI groups with an average debt ratio of 13.0%--versus 30.0% for the Industrial Chemicals group.

Most of the leading suppliers (Appendix 5-4) of specialty chemicals for water and wastewater treatment are in the size range of $100 MM to $400 MM in annual corporate sales. Merck (Calgon) and W. R. Grace (Chemed) are billion-dollar corporations with leading positions. Other billion-dollar chemical companies serving this business generally do so through the sale of bulk (commodity) chemicals.

5.6 SOLID WASTE MANAGEMENT

The Solid Waste Management (SWM) group is not yet representative of the Resource Recovery business as the market is still in its embryonic stages. Hence, the financial statistics for the group are only indicative of the kind of company participating in this market. Return on Assets averaged 5.0% (Table 5-6) for SWM companies, but the group was outperformed by the comparative Industrial Machinery composite group with an average ROA of 7.7% over the same period.

The SWM group had an average corporate Return on Sales of 4.5% from 1972-1976. Again, the Industrial Machinery composite realized a higher Return on Sales of 5.9%.

Leading participants in this newest of PCI business sectors are divided into two groups. The first group is comprised of many companies serving other PCI sectors and lie in the size range of $100 MM to $700 MM in annual corporate sales. However, this new market is also served by a sizable group of billion-dollar corporations--although none of them are yet among the top three or four suppliers. (See Appendix 5-5.)

TABLE 5-5

WATER TREATMENT CHEMICAL MANUFACTURERS

Average Annual Growth 1972-1976:	WT Chem Companies	Industrial Chemicals Composite	All Manufacturing
Corporate Sales:	22.0%	16.8%	9.1%
Corporate After Tax Income:	20.4%	17.9%	15.3%
Corporate Assets:	17.1%	13.6%	--

	1972	1973	1974	1975	1976	Average 1972-1976
Return on Assets %:						
WT Chem	11.4	10.2	9.5	10.3	10.2	10.3
Industrial Chemicals	6.1	7.7	8.7	6.7	7.1	7.3
Return on Equity %:						
WT Chem	13.2	14.9	14.7	15.9	17.8	15.3
Industrial Chemicals	11.2	14.5	17.1	13.4	14.4	14.1
Return on Investment %:						
WT Chem	13.2	13.7	14.1	14.9	16.6	14.5
Industrial Chemicals	8.0	9.9	11.1	9.4	9.8	9.6
Return on Sales %:						
WT Chem	7.4	7.6	6.8	7.1	7.3	7.2
Industrial Chemicals	6.4	7.7	7.7	6.4	6.7	6.9
Debt to Capital %:						
WT Chem	10.0	14	15	16	9	13
Industrial Chemicals	29.0	28	29	31	33	30

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poors' Industry Survey.

TABLE 5-6

SOLID WASTE MANAGEMENT SYSTEMS SUPPLIERS

Average Annual Growth 1972-1976:	SWM Companies	Industrial Machinery Composite	All Manufacturing
Corporate Sales:	17.5%	17.7%	9.1%
Corporate After Tax Income:	13.1%	10.8%	15.3%
Corporate Assets:	15.0%	15.9%	--

	1972	1973	1974	1975	1976	Average 1972-1976
Return on Assets %:						
SWM Group	5.9	5.7	4.6	3.7	5.1	5.0
Industrial Machinery	8.0	8.5	7.6	7.4	6.7	7.7
Return on Equity %:						
SWM Group	10.5	11.5	10.5	8.2	11.7	10.5
Industrial Machinery	13.1	15.3	14.9	14.1	12.6	14.0
Return on Investment %:						
SWM Group	8.3	9.4	9.3	8.1	9.6	8.9
Industrial Machinery	10.0	11.2	11.0	10.8	9.8	10.6
Return on Sales %:						
SWM Group	5.2	5.3	4.2	3.3	4.4	4.5
Industrial Machinery	6.5	6.5	5.8	5.7	5.1	5.9
Debt to Capital %:						
SWM Group	22	30	36	38	33	32
Industrial Machinery	19	20	26	26	25	23

Source: Corporate Annual Reports, Security Exchange Commission Forms 10-K, Moody's Industrial Manual, and Standard and Poors' Industry Survey.

5.7 GENERAL ISSUES

The PCI has been experiencing a kind of "profitless prosperity." This does not imply that the industry has not made money. Its profitability has been about average for American industry--with occasional periods of lower profitability. (An exception to this is the water treatment chemical sector which has been quite profitable.) "Profitless prosperity" in this case dramatizes a "disappointment in profits" which has become common in this growth market. Growing industries typically provide opportunities for higher profitabilities which in turn can provide the basis for aggressive business investments. Average (or lower) profitability has worked against new investment by the PCI.

In the wastewater treatment segments, most of the companies view the industrial market as more profitable than the municipal market. Yet the opportunities for volume participation by the leaders in industrial wastewater treatment equipment are less than in the municipal sector. For one thing, the sizes of individual jobs are considerably smaller in the industrial market. Inflation is less of a problem in the industrial market because of the shorter lead times between the order and delivery.

Most companies report that profitability has recovered in the wastewater treatment business in recent years. Improved profitability is traced to better management of the companies and to a recovery from the fixed price contract problems of the 1973-1975 period. Profit margins are still believed to be low, if not declining, and there are signs that fixed price contracting is returning to the business as a result of competitive pressures.

The air pollution control business is viewed by many participants as more of a construction business than it is an equipment business. For that reason, demand estimates on a flange-to-flange basis are becoming less and less meaningful. In resource recovery, as well as in the FGD sector of the air pollution control market, it is believed that few, if any, companies have yet to make significant profits. Yet these two markets have been and will continue to be among the fastest growing sectors in the PCI. A combination of intense competition and delayed market development has hurt the profitability of these businesses and has already dampened enthusiasm for their future.

It is important to warn that the analyses provided above are composite ones. There is a range of experience to be found within each of the PCI sectors. While some companies may find their wastewater treatment businesses to be less profitable than their other businesses, in some years the reverse may be true. Where some companies believe the air pollution control business to be no longer worthy of further investment, other companies have found it to be more profitable than their other businesses--including wastewater treatment.

Finally, the leading companies in PCI market sectors are not financially strong in the sense that billion-dollar corporations are strong. The largest of these companies (with participation greater than 10% of total corporate sales) typically falls in the bottom third of the Fortune 500. In this respect, the Nation's dependence upon this industry to solve the societal problems of pollution control is more tenuous than it is upon industries serving other governmental program areas, e.g., energy, health care, and aerospace. Not only is profitability insufficient to encourage new development, but it is also not an industry of billion-dollar companies able and willing to risk investments on opportunities which are dependent on regulatory enforcement.

6.0 TECHNOLOGY ISSUES

6.1 STATUS AND NEEDS FOR TECHNOLOGY

The status of available technology in the PCI and the needs for new technologies as perceived by the industry vary significantly among the major sectors. These variations generally relate to the relative maturity of the sectors. The PCI evinced a greater concern for the need to develop technologies in the resource recovery field than in the air and water pollution control fields. The age of applicable Federal regulations also correlates well with the status and perceived needs for technologies. As water and air pollution control legislation antedates the solid waste (i.e., RCRA) legislation, the forcing of technology has resulted in a greater technological maturity in air and water pollution control.

6.1.1 Water Pollution Control

Many spokesmen in the PCI believe that water pollution control equipment technology is well developed. This belief is partly based on the perception that relatively few new products have been introduced in recent years. Our discussions indicated that energy-intensive technologies are high on the PCI's list of perceived needs for technology improvement or development--including the needs for improving sludge treatment and handling technology. Among the most frequently cited recent developments, for example, was the trend toward the use of filter presses and belt filters for sludge dewatering as replacement for the more energy intensive vacuum filters and centrifuges.

Perhaps the greatest needs lie (1) in the development of complete systems which would probably utilize the same type of equipment as now available and (2) in the development of in-line instrumentation. For example, the need for phosphate and nitrogen analyzers was cited; but simultaneously it was stated that the development would probably not be worth the financial efforts involved. Regulatory requirements for reporting the quality of the wastewater effluents are usually based upon grab or composite samples. There is a high degree of maintenance required for in-line, sophisticated sampling and analytical systems such as for total organic carbon (TOC). There are also inherent process difficulties in continuous treatment of streams of often widely varying compositions. These are some of the mitigating reasons working against significant instrumentation research and development efforts by the PCI.

Several companies mentioned the control of toxic substances as a potential new technological frontier. However, it was suggested that the EPA should not expect the PCI to develop the technologies for toxics control prior to the uncertain promulgation of regulations. In that sense, any end-of-pipe control for toxics would likely come from technologies available at the time. Actually, the industry perceives only a limited market for toxic removal technologies.

At least one company noted that their research and development efforts in the 50's and 60's were directed toward the municipal markets. Such developments were then "spun off" into the industrial markets. Now the converse is true, i.e., little effort is being spent in R&D efforts for the municipal markets. One cause of this reversal is the municipal bidding system which is believed to discourage technological innovation.

New water pollution control technologies tend to be "unique" product innovations rather than proprietary technologies. Future versions of these "unique" products will be principally variations of well-known wastewater treatment processes which better deal with site-specific requirements, specific wastewater compositions, or special discharge limits.

6.1.2 Air Pollution Control

The APC segment of the PCI divides its concerns for technology into (1) particulates and (2) gases. A common perception in the industry is that particulate control technologies are well developed and that further technological developments in particulate removal efficiency will come with increasingly greater difficulty.

The particulate removal technologies currently installed are those with the lowest economic cost to the industries and not necessarily those technologies having the highest particulate removal efficiencies. As increased overall removal efficiencies and removal of submicron particles are required, electrostatic precipitators will become less competitive relative to fabric filters. Such a trend will result increasingly in complicated market trade-offs among technologies, economics, and regulations.

The removal of gaseous pollutants such as sulfur oxides and nitrogen oxides are seen to be the areas of principal technological concern. The need for further development of sulfur oxide removal technology continues to dominate the needs related to gaseous pollutants. There is nowhere near as great a consensus on the availability of sulfur oxide removal technologies as particulate removal technologies. Some companies believe that FGD systems are adequately developed for the removal of sulfur oxides. Other companies perceive that improved systems must still be developed. It is generally recognized that the cost effectiveness of sulfur oxide removal is improving (in terms of real dollars) with increasing experience in design and operation.

The problems of sludge disposal from the FGD systems are recognized, but there is no clear consensus in the industry on the status of technology for dealing with these sludges. Comments ranged all the way from "no problems" to "significant problems"--partly depending upon the direction in which RCRA regulations develop. Some segments of the industry perceive that sulfur oxide control systems based on recovery of sulfur will not be very significant. Others see the systems for removal of sulfur oxides becoming important.

Although the industry perceives NO_x and hydrocarbons as becoming more important from the regulatory side, it does not perceive that the needs for new control technology development will be very significant. Many of the relevant control technologies for these gases will involve process changes, changing the conditions of combustion, or the use of adsorbents, etc. Applicable gaseous control technologies are considered to be reasonably well known but expensive. Among these, high-energy-using and high-maintenance systems are likely to be among the initial targets for technological development. There is a much greater range of technologies applicable to the control of gaseous pollutants than for particulates, but most of these gaseous control technologies have not yet been demonstrated over as long a time period.

6.1.3 Resource Recovery

Resource recovery technology is principally related to the recovery of energy from municipal solid waste (MSW). There is less attention being given at the present time to technologies that might be more applicable to industrial applications. In resource recovery, there are no technologies with clear-cut leadership. It is largely a field of unproven technologies--especially in the United States--and a field where European-developed technologies will be the leader in the short-term at least. The dominant approaches are expected to be steam generation by waterwall incineration or refuse derived fuel (RDF). The PCI perceives that much demonstration work will be required before the latter is confirmed. The general consensus is that the projected near-term role of pyrolysis is declining, although co-disposal by pyrolysis of MSW and sewage sludge remains potentially viable.

6.2 INDUSTRY CAPABILITIES

6.2.1 Company Efforts

The heart of the PCI, the equipment companies, has not been traditionally strong in research and development. R&D expenditures for 14 of these companies* in 1976 averaged 1.2% of sales. The leaders** in water treatment chemicals averaged 3.0% of sales. Seven instrumentation suppliers,*** selling more to non-pollution businesses, averaged 5.0% of sales. By comparison, R&D by the Chemical Industry averages 2.5 - 3.0% of sales.

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*American Air Filter, Babcock & Wilcox, Bird & Son, Carborundum, Chicago Bridge & Iron, Combustion Engineering, Dresser, Envirotech, Joy Manufacturing, Peabody International, Research-Cottrell, Rexnord, U. S. Filter, and Wheelabrator-Frye.

**Betz and Nalco.

***Beckman, Fischer & Porter, Foxboro, General Signal, Honeywell, Leeds & Northrup, and Technicon.

As R&D budgets are not now large for the PCI equipment suppliers, so it has been historically. The sewage treatment and dust collection businesses which predated recent environmental legislation were businesses of established technology. Hence the histories, the current priorities, and the capabilities of PCI equipment suppliers are not terribly well suited to satisfy significant R&D requirements of new EPA programs. In that way, this industry differs markedly from the industries which relate to other Federal programs, e.g., aerospace, health care, and energy.

PCI companies are principally concerned with the demonstration of new systems and products as opposed to the research and development of new technologies, per se. Although some companies allocate appreciable expenditures of time and monies to basic R&D, we perceive that the major efforts are committed to development and demonstration. In general, the industry is constrained in its research and development efforts by disappointing profit levels. That which is done tends to be predicated upon achieving a short-term pay-off.

The companies which have the most effort into technology development are those with strong backgrounds in research and development in other industries, e.g., chemicals, petroleum and aerospace. Yet these companies often lack the marketing base to commercialize their developments.

We perceive that long established PCI companies are much less likely to commit as much effort to the development of new technologies. It has not been necessary for their historical businesses, and it has not been all that important in pollution control to the present time.

A general consensus is that it takes two to five years to develop a new product coupled with as much as another five years to attain good market acceptance. This supports the broadly-held rationale that a PCI company will not get its money back from concerted R&D efforts. While some companies do see a need for more R&D, they simultaneously see little profit incentive and an uncertain demand for new technology. Several companies cited their past experiences with market uncertainties and unclear regulatory directions as contributing to a cutting back in their efforts to develop new products.

The PCI's efforts in technology development are hence largely limited to improving the performance of present equipment and the demonstration of new processes. The minimal efforts of the PCI companies in technology development are those of an industry with relatively low profit margins whose principal products are sold to "reluctant" customers. It is only in areas of relatively new pollution control problems that major R&D efforts are to be found, e.g., FGD and resource recovery systems.

6.2.2 Process Oriented Approaches

Process approaches to pollution control, i.e., modification of the manufacturing processes and operating conditions may require the in-depth technical and engineering expertise usually found in the large engineering-construction firms. The process design and modification approach may be generally beyond the capabilities of many PCI companies, although some view this as a major area for diversification. There was a general feeling that pollutant specific regulations now being developed by EPA will most likely be met by process changes rather than by traditional pollution control equipment.

Based on our knowledge of the PCI and of the engineering-construction companies, we believe that there are only relatively few of the larger, diversified PCI companies that could be successful in providing process oriented approaches to controlling pollution. By far, the majority of the PCI companies will remain as suppliers of equipment for either "end-of-pipe" pollution control or for integration into processes designed and developed by others.

6.3 NEEDS FOR EPA'S R&D EFFORTS

6.3.1 Value of EPA R&D to Date

The PCI generally concludes that the greatest value from EPA R&D efforts to date stems from demonstration projects. Because of the traditional reluctance of purchasers of pollution control equipment, the funding of demonstration projects is perceived as being instrumental in proving pollution control technologies. However, it is broadly felt that most of these demonstration projects have been product improvement oriented, i.e., allowing a particular supplier to prove the capabilities of its equipment.

Some are of the opinion that EPA's R&D efforts obstruct the competitive process, and that a major Federal R&D effort is not needed. Some commenters believe that EPA demonstration projects for solving a problem (i.e., proving that a regulation can be met) result mostly in business for the larger, well-established PCI firms. However, in at least one instance, it was conceded that EPA-funded R&D was a significant factor in the development of the U. S. market for a European wastewater treatment technology by a small U. S. company.

6.3.2 Interest in EPA-Funded Contracts

The interest in EPA-funded contracts among the PCI was found to vary widely. On the question of patents, the comments ranged all the way from "too important to risk possible government assignment" to "patents aren't really that important." More attractive patent disclosure procedures were cited by several companies as their reason for being more interested in R&D contracts with EPRI and DOE than with EPA. Some companies perceive that the "know-how" gained from an EPA-funded contract may balance out any loss of patent rights.

The most interesting EPA-funded contracts appear to be in demonstration. After patent protection has been obtained, many PCI firms then see EPA funding as a means to demonstrate performance in pilot plant and full-scale installation. In other words, we perceive the PCI to be most interested in obtaining EPA funding which will allow them to "work out the bugs." It is also our perception that those PCI firms in wastewater treatment with the largest R&D efforts of their own also tend to be most favorably disposed to EPA-funded R&D work.

A common perception is that too many of EPA's R&D contracts go to companies with "the least commitment to the business." These companies are perceived as being interested principally in research and development and not attuned to needs in the marketplace. Others reported that the difficulties and delays in obtaining EPA R&D contracts did not warrant the effort. While there was considerable interest in demonstration-type contracts, one company said that it does not pursue EPA R&D contracts because it may tend to alienate some of their reluctant customers.

6.3.3 Suggested Future Priorities

The two most frequently favored priorities for EPA R&D efforts were: (a) research on health effects and (b.) demonstration projects. There was a general consensus that research and development on "hardware" should not be an EPA priority. The PCI clearly sees the value of health effects research as necessary to establish the pollutants to be controlled. It also finds demonstration projects as important in expediting the installation of control technologies under regulatory pressures.

Comments relative to APC ranged from "no reason for EPA R&D funding" to "more research is needed on control mechanisms." The suggestion was made that EPA limit its efforts to those areas where no one else is going to do the R&D work and to where there is likely to be the biggest impact. Another suggestion was that EPA consider funding "joint development grants" with the PCI; another felt that EPA should not be involved in development at all.

These responses are from an industry which is largely dependent upon regulatory pressures for the size and growth of its markets. In concise terms, the PCI wants clearer guidance on where regulatory pressures are going to create the greatest markets. It desires financial assistance in the development of the products needed for an uncertain enforcement market. At the same time it would naturally prefer to retain full rights to the know-how and patents that might accrue.

7.0 AVAILABILITY OF CAPACITY, SUPPLY, AND COMPETITION

A natural concern for any governmental program depending upon a private sector industry is that sufficient capability exist to supply the needs of the program.

The potential for a problem of insufficient capacity lies mostly in the peaks of demand which might test the capability of a broad PCI sector. Very early in our discussions with PCI representatives, we were able to confirm that capacity is not currently a problem; nor is it expected to be in the near future.

As in 1973 and 1974, the supply of pollution control systems can also be constrained by shortages of raw materials, system components, or auxiliary equipment. Although there continue to be delays in the delivery of a few components and pieces of auxiliary equipment, there are no major supply constraints of this type now on the horizon.

There appears to be no shortage of competitors, competition, or potential competition within the major sectors of the PCI. Most PCI members would call that an understatement. If there were an insufficient number of competitors or significant barriers to entry across broad market sectors, price escalation might result in a legislated market.

7.1 CHARACTERIZATION OF CAPACITY

A typical PCI plant is not so much a manufacturing facility as it is an assembly operation. Variations on this distinction occur across the PCI. The leading water treatment specialty chemical companies are generally formulators and not basic chemical manufacturers. Air pollution control equipment suppliers are viewing their business more and more as contracting and construction and less that of flange-to-flange equipment supply.

The capacity of the equipment sectors of the PCI is made flexible by the high level of dependence upon outside fabricating shops. Fabrication practice varies from almost total in-house fabrication by some suppliers to almost total dependence on outside fabricators by others. It is not uncommon for equipment suppliers to be selective in the products that they choose to produce in-house; many farm out 75% to 80% of their fabrication requirements. Similarly, construction contracts may be subcontracted to local specialized firms.

There would appear to be no concern about the near-term availability of outside fabricating shops. At most, there might be some concern about the availability of quality shops in peak demand periods. The manufacturers have reported no major problems in getting this outside support.

This dependence upon independent fabricators reduces the threat of a capacity shortage to regulatory initiatives. Fabrication capacity is a low investment kind of facility as manufacturing plants go. In addition, the ability to depend on non-company shops reduces the investment requirements and the associated risks for this industry of average profitability. It is one way in which a company may deal with the cycles in its business. One of the reasons why this option is important is that the technologies of pollution control systems to date have not been of a highly proprietary nature--i.e., they are generally suited to outside fabrication.

Partly because of this reliance upon outside fabricators, there is generally no shortage of capacity in the industry at this time. Certainly, shortages could occur if demand were to peak in an unusual manner or in response to an unanticipated regulatory initiative.

There are competitive reasons why PCI participants might not want to state that there is a capacity shortage (i.e., and invite others to come in), but it is not uncommon for a manufacturer to boast that a plant is running "flat out" when business is going well. We heard no reports of capacity shortages and heard only a few reports of companies running at or near their in-house capacities to supply systems.

If anything, the PCI industry currently suffers from some of the opposite problem, i.e., overcapacity. Where a company has built a new manufacturing facility in the last five years or so, it is not uncommon for them to report low rates of plant utilization. This kind of experience has been sufficiently common in recent years to teach most PCI companies a significant lesson. The basis for such overcapacity has usually been overinvestment in advance of the anticipated demand tied to legislative deadlines and expected enforcement initiatives. This has happened most notably in the WPC equipment sector, the WPC instrumentation sector, and the FGD segment of the air pollution control business. Companies with considerable overcapacity are committed to not making the same error again in the future. Not many investments in plant facilities are being planned in this industry at this time.

The most limiting factor in PCI capability to deliver systems may not be plant capacity as much as it is manpower. Engineers and skilled manpower are viewed as almost a fixed cost of the business. A deficit of highly skilled labor required for installing major pollution control systems is, for example, seen as one possible shortage that could be created. When business is booming, these companies cannot as easily subcontract the design and construction management tasks as they can fabrication requirements. When business is lean, these companies may lay off hourly paid workers but hesitate to lay off skilled and engineering staff.

7.2 POTENTIAL SUPPLY CONSTRAINTS AND BOTTLENECKS

No critical shortages in raw materials, components, or auxiliary equipment are in evidence in today's market or expected to be a factor very soon. The memories of the 1973-74 shortages in steel plate, steel sheet, and shop space are still strong, but no repeat of that situation is foreseen.

Bottlenecks in supply do appear in terms of extended delivery delays in items such as fans, motors, and pumps. One reason for this is that pollution control systems often require specialty versions of these items. Delivery delays are currently more than a year on some of these items. There are also occasional bottlenecks in the supply of chromium and stainless steel materials. It was also reported that fiberglass for fabric filters has been in short supply in recent times. This could become a greater problem if fabric filters become proven and dominant in utility boiler applications. There have also been occasional shortages in electric equipment and structurals. Bottlenecks may also occur when suppliers reduce their inventories with downturns in their business.

7.3 STATUS AND TRENDS IN COMPETITION

7.3.1 Air Pollution Control Equipment

Probably 200-300 firms participate in the air pollution control market, but about 15 companies account for 60-70% of the current business volume. The top eight firms include: American Air Filter, Combustion Engineering, Combustion Equipment Associates, Inc., Envirotech, Joy Manufacturing, Research-Cottrell, U. S. Filter, and Wheelabrator-Frye. Those eight firms account for 50-60% of the market. The leading firm, Research-Cottrell, probably has 12-15% of the business. Other selected participants are indicated in Appendix 7.

The competition in the emerging FGD business is somewhat different from the above line-up in the traditional particulate control business. The leaders in SO_2 control include: Babcock & Wilcox, Combustion Engineering, Combustion Equipment Associates, Inc., Envirotech (Chemico), Research-Cottrell, and UOP.

7.3.2 Instrumentation

The major characteristic of the instrumentation companies is that only a minor part of their businesses typically lie in pollution control applications. Very few of them enjoy as much as 10% of their total business in pollution control. Leading firms in air pollution control instrumentation include: Beckman, Bendix, and Lear Siegler. Leaders in water pollution control instrumentation include: Fischer & Porter, Foxboro, General Signal, and Leeds & Northrup.

7.3.3 Water Pollution Control Equipment

Probably 400-500 firms participate in this market. Twenty to thirty of these firms account for 70-80% of the total business. The top eight firms include: Dorr-Oliver, Envirotech, FMC, Neptune International, Peabody International, Pennwalt, Rexnord (Envirex), and Trans Union

(Ecodyne). These eight firms account for roughly 50% of the market; the top firm, Envirotech, probably holds a 10-12% market share. Other participants in this business are indicated in Appendix 7.

The business is probably less concentrated today among the leadership than it was five years ago. This has been primarily caused by increased competition from smaller, local firms in the municipal sewage treatment segment. Envirotech and Rexnord share leadership in the municipal segment while Envirotech is the dominant supplier to the industrial market.

7.3.4 Water Treatment Chemicals

It is commonly believed that six firms control 50% of the market for specialty chemicals in water pollution control applications. These six firms are: Betz, Dexter (Mogul), Merck (Calgon), Nalco, U. S. Filter (Drew), and W. R. Grace (Chemed/Dearborn). The next level of competition primarily consists of regional suppliers or specialists in individual industry applications. Suppliers of bulk chemicals for water pollution control applications typically enjoy only a minor percentage of their business for any one product in water treatment applications. Some of these companies are also listed in Appendix 7.

7.3.5 Resource Recovery

Probably 20-30 companies should be considered as potential participants in this still embryonic market. Leading participants at the present time include: Black Clawson, Combustion Equipment Associates/Occidental Petroleum, Waste Management, and Wheelabrator-Frye. A second tier of companies includes: American Can (Americology), Browning-Ferris, Raytheon, and Teledyne. Other participants are indicated in Appendix 7.

Participation in this emerging industry is coming from several different quarters. Environmental companies like Envirotech, Combustion Equipment Associates, and Wheelabrator-Frye represent one group. Solid waste management companies like Waste Management and Browning-Ferris represent another. American Can, Occidental Petroleum, and Raytheon represent a group of Fortune 200-type corporations which have entered this business in its early stages.

7.3.6 Foreign Markets and Competition

Direct competition from foreign companies has not yet been a significant factor in most domestic pollution control markets. In equipment sectors, the business has been most impacted by foreign technologies brought to the domestic market through domestic suppliers and licensees. The one exception to this has been the instrumentation sector where a group of companies like Braun, Hariba, Hartmann, Philips, and Susman has achieved market shares of 10% or more in different segments. Generally speaking, the foreign equipment suppliers who have tried to enter the U. S. market have not done as well.

To the extent that foreign competition has enjoyed any business in the United States, domestic suppliers have more than made up for that in their own export business. The export markets for domestic suppliers have gyrated somewhat in recent years and are largely limited to the supply of systems fabricated abroad. Hence, the amount of U. S. balance-of-trade effects provided by the PCI is small.

In recent years, the importance of foreign technology has increased in the U. S. marketplace. In air pollution control, European technology has been one source of second generation technology in electrostatic precipitators. Japan has been a significant source of FGD technology. In water pollution control, belt filters and rotating biological contactors were developed originally in Europe. As Europe has been longer affected by a need to conserve energy, foreign technologies can be expected to play a greater role as energy conservation is given more attention. As noted above, foreign technology has had a substantial impact in the instrumentation marketplace. In resource recovery, both waterwall incineration and pyrolysis have been developed abroad.

This growing role of foreign technology provides another backdrop to the discussion in Chapter 6 on technological needs and the resources of this industry to supply those needs. The fact that foreign technologies have been brought in to better solve U. S. pollution problems seems to argue against a position that no further technology is needed. The fact that foreign technology has become an increasing source of innovation to the pollution control industry partly reflects EPA's encouragement to consider all available control approaches. It may also reflect some basic problems which constrain the development of new technologies by the PCI, its customer industries, and EPA. The United States is not playing a leadership role in the basic research and development of new pollution control technologies. Its leadership is better seen in the application know-how, and implementation of technologies.

7.4 GENERAL ISSUES

The industry seems to be in a phase of expanding competition rather than one of consolidation. Each new emerging market seems to attract more than the needed number of competitors from both within and without the PCI. This has been true in FGD systems, in resource recovery, in membrane systems, in belt filters, and several other areas.

Many observers look for a significant shakeout of competition over the next few years. We believe that the interest in this market is such that for each company leaving the marketplace, there will be another company to replace it. In short, we foresee that turnover--not shakeout--will continue to characterize this market over the near-term.

While the ease of entry into both established and new markets seems sufficient to ensure healthy competition, the barriers to leadership in established markets are still great. Over the last ten years, the opportunities in pollution control have attracted a great deal of diversification interest. A large number of billion-dollar, Fortune-200-type firms have made significant efforts to penetrate these businesses. Not one of these has yet succeeded in carving out a leadership position in a broad segment of the PCI. There has been significant turnover among the leaders in these markets, but they have been the ones who were well-established before.

The major barrier to leadership in most of the markets is not technology and not financial strength, but marketing. Market leadership is most protected by know-how in applying pollution control technologies, in knowledge of customers and their problems, and in general marketing competence.

One competitive problem is possible in the air pollution control field and deserves monitoring. There, half of the business is tied up in the supply of pollution control systems to electric power utilities. Most of the current business in FGD systems is already tied to new sources. The problem could lie in the tendency of utilities to purchase their pollution control systems as a package or in combination with their process needs. Package purchases are found more desirable by the smaller utilities.

The advantage of companies with broad product pollution control lines has been, to some extent, balanced by competitors joining in a combined bid package. (Suppliers of electrostatic precipitators will get together with an FGD system supplier to bid against a supplier of both systems.) The opportunities for joint bidding of process and pollution control systems may be more constraining. Most of the boiler manufacturers, for example, have their own pollution control system capabilities. However, a significant group of air pollution control suppliers has long served the utility industry with particulate control systems under similar circumstances.

8.0 CORPORATE COMMITMENTS AND BUSINESS RISKS

8.1 CORPORATE COMMITMENTS

8.1.1 Water Pollution Control

Corporate attitudes of WPC companies towards the WPC business tend to be dominated by experiences in the municipal market segment. The increasing importance of "low bid" purchasing, an erratic flow of progress payments, the commodity-like competition, and the uncertain timing of the funding process have led to widespread disenchantment.

A mix of experience was reported by the companies we interviewed on the profitability of their WPC business compared to the rest of their businesses. For many, this business was at or near the bottom of the corporate portfolio. Where profitability had improved in recent years, top management was reported to retain memories of earlier years of lower profitability in their consideration of further investments. On the other hand, several companies have found this business to be more profitable than most of their other businesses.

One of the factors which undermines commitment to the WPC business in diversified corporations is that it often may not represent much more than 5 or 10% of the total corporate volume. An associated reality is that many corporate managements simply don't understand the WPC business and don't feel comfortable with its "municipal business" segment.

The staying power necessary to continue in the WPC business was reported to include patience, an investment in people, financial resources, and limited short-term expectations.

8.1.2 Air Pollution Control

We also found a range of attitudes and commitments towards the pollution control business in the APC sector. We found companies which intend to stick with the business through its periods of disenchantment, its delays, and its changing technological groundrules. Commitment tended to be strongest in those companies in which pollution control was a larger part of the total corporate business or where larger, related businesses provided a base for a pollution control activity.

Accordingly, where APC represents a small part of the total corporate business, there is more pressure for the APC business to be profitable and less inclination towards a commitment to APC for its own sake.

In the instrumentation segment of both APC and WPC sectors, the market is viewed as a relatively small one among all the markets for instrumentation. Instrumentation manufacturers are likely to put a very low priority on this business for that reason and because of the general disenchantment which they have shared with the equipment manufacturers.

We were surprised to discover that several leading APC companies are making plans either to vacate parts of the pollution control business or to significantly reduce the corporation's dependence on it. In the FGD business segment, companies were heard to say that they would be getting out of it if it continues in its present state.

There are some common directions for those suppliers who are moving away from the mainstream of air pollution control. Quite a few are emphasizing diversification into energy and energy-related businesses. Entrees for several companies into energy-related businesses lie in corporate involvements in combustion technologies. Others are simply shifting into what they view to be a more broadly defined business of environmental management, including process as well as end-of-stack approaches.

8.1.3 Resource Recovery

Within our smaller sample of companies serving the emerging resource recovery business, we found fewer signs of disenchantment or plans for de-emphasis. There are a few companies which have already had major disappointments and which do appear to be retreating from the business. Expectations among most participants continue to run high, and corporate commitments reflect that optimism. It's a high-priority business for future corporate growth in some of these companies. With others, corporate commitment is just beginning to grow.

There is an interesting anomaly regarding commitment to resource recovery businesses. Financial resources and staying power would appear to be the keys to success. Companies which would appear to have that strength are those from the Fortune 200. Yet these companies appeared to be the ones more likely to favor Federal funding in this business to reduce the risks in the early demonstration market.

Companies which have entered this business from positions in other pollution control markets are the ones most likely to be committed to this business at this time. These prefer that there be less dependence upon regulatory activity or Federal funding.

For those companies committed to this business, it is not uncommon for them not to expect it to be a major factor for them for another five years. Once again, long-term commitment is reasoned to be important in order to survive market or profitability problems in the short-term.

8.2 RISK FACTORS

The concept of a "legislated market" would appear to promise a less risky business environment. However, the pollution control business has come to be viewed by its leading participants as very much a "risky" business.

To better understand the dimensions of risk in the PCI, we discussed this and related issues with each of the companies we contacted. We have not made theoretical analysis on whether these risks do in fact make the pollution control business riskier than other businesses. Neither have we attempted to quantify these risks or to compare them to the industry's returns.

What many PCI participants are arguing is that the returns from these businesses are not worth the risks associated with them. The outcome of that comparison in turn affects corporate commitment and the willingness to invest further in pollution control business capabilities.

8.2.1 Water Pollution Control

Dependence on the municipal segment of the water pollution control business is considered to be an important element of risk. This is in contrast to the anticipation of assured market growth which prevailed when the Federal funding programs began. One of the major problems has been the gap between authorized funding levels and subsequent expenditures activities. Now that impoundments by the Administration appear to be a problem of the past, the industry's confidence in future funding levels has increased.

Risk is associated with the variance of waste streams within an industrial facility and the need for WPC systems to handle a broad range of these wastes. Performance guarantees, competitive effects upon system design, and the possibility of process upsets are parts of this risk.

Above-average and above-anticipated inflation rates have proven to be another risk. Inflation in WPC facility construction costs has increased faster than that experienced by the general economy. The risks of inflation increase directly with the amount of time between order and final delivery--hence they are greater in the municipal segment. WPC companies have worked hard to correct the problems of fixed-price-contracts during the inflationary and shortage times of 1973-74. Yet when business is down and competition is hungry, contractual safeguards tend to be sacrificed.

A technological risk is that research and development efforts can be made obsolete by regulatory shifts before those developments are completed. New WPC products or technologies are believed to take three to five years to develop. Market acceptance may add a few more years to that process. New regulatory initiatives or directions may correspondingly begin and mature in a year's time.

A major financial risk is the potential overinvestment in manufacturing facilities which can occur when anticipated demand becomes delayed or even eliminated by market and regulatory factors. A related risk is the uncertainty over enforcement of a regulation. The other side of this risk is that of lost opportunity if it is enforced and the company hasn't built a capability to meet the demand.

Another risk element may lie in a lack of regulatory consistency concerning standards or acceptable compliance. A lack of consistency between EPA regions, states, and other authorities reduces the confidence of pollution control customers in the long-term value of their investment. This uncertainty then becomes transferred to business uncertainty for the equipment vendor.

The water pollution control business is a cyclical business and, therefore, risky even though it may be countercyclical to the general business cycle. The business is likely to become more in phase with the general business cycle as it relates more and more to new construction.

One observer described the risk associated with this legislated market to be that of the changing policies and changing minds of governmental agencies. A regulatory risk is simply that of being able to predict Congressional actions and EPA initiatives.

A technological risk is associated with commodity markets comprised of off-the-shelf systems. This reduces the proprietary leverage for the returns needed to balance the other risks of the business. In this sense, the industry's returns may correlate well to a business of "low technology," but they do not seem to correlate to its general risks.

Over the years, the opportunity to provide "turnkey" systems to both municipal and industrial customers has been viewed as a major opportunity. Attempts by several companies to provide turnkey systems have uncovered substantial financial risks associated with that responsibility.

A business and technological risk is the dependence of WPC system operation upon the operating skills of the customer. In the municipal segment, the level of skills and the availability of skilled operators will continue to endanger the operating performance of WPC systems and the derivative reputation of the WPC vendors. Another element of risk in the municipal segment is that the consulting engineer is taking less and less responsibility. Insufficient importance is being placed upon design, system flexibility, and long-term operation. Many suppliers see "unlimited liabilities" in the municipal segment if the vendors are made ultimately responsible for low-price systems that do not work. These risks include the costs of service calls to deal with these operating problems.

In the municipal segment, the vendors believe there are real risks in a system that is unilaterally designed by the customer and in which the vendors appear to have little leverage in dispute situations. Guarantees of performance in the municipal segment are considered risky as there are many factors which can undermine the ability to guarantee system performance.

8.2.2 Air Pollution Control

A general risk is the realistic possibility that any system can fail to meet guarantees for reasons both within and outside the control of the vendor. The risks associated with guarantees in the control of emissions from power plant stacks are among the largest in the PCI. A generic risk in any buyer's market is that guarantees of performance are necessarily forced upon the vendors who must accept that responsibility or be non-competitive. These risks will grow with the increasing size of the projects and the requirements of performance at or beyond vendor experience.

Operating risks lie in the regulatory uncertainty associated with a legislated APC market. This impedes attempts by suppliers to do effective business planning, to build inventory, to build staff, or to build plants. A commonly held belief is that the more regulated parts of these markets are the least desirable ones.

There is the general risk of selling systems to reluctant customers who are not exactly in favor of the purchase in the first place nor dedicated to the operation of the system when it's in place.

As in WPC, there are risks associated with the time delays: to develop new technologies, to gain market acceptance, and to demonstrate performance -- versus the shorter times in which regulatory requirements can change. This dampens the industry's interest in R&D, technical innovation, and new commercial ventures.

Many of these companies view this business as less stable than their other businesses and as being the riskiest business in their corporate portfolio.

8.2.3 Resource Recovery

The risks of the emerging resource recovery market include many of the ones above. More will probably be discovered as the business matures.

Similar to other emerging markets, the risks of resource recovery are also tied to the uncertain economics of resource recovery systems and the risks associated with finally demonstrating the performance of leading technologies. Another corporate risk in resource recovery lies in the local politics and criminal elements often associated with the solid waste business. There is a related danger of sabotage.

A significantly different risk in resource recovery is related to the hazards which can result from the combination of resource recovery technologies and the components of the municipal waste stream. Modern technologies to handle municipal solid waste are dependent upon diligent operation of the facility which may be largely thermal (and, therefore, potentially explosive) technologies. The indigenous, municipal problem of getting and holding skilled operators presents a risk which will become more evident as these systems gain operating experience.

8.3 GENERAL ISSUES

We talked to both line managers and top management in our tour of the PCI. There is no statistical significance in our sample, but we discerned an apparent and natural difference in commitment between the two groups.

When we talked to line managers, we tended to get the impression of a strong corporate commitment to remain in the mainstream of the business. The responsibilities of most of these people were for marketing, technological development, and day-to-day management of ongoing pollution control businesses. Their responsibilities include recommendations to top management; hence, they are inclined to err on the optimistic side in order to better compete with other investment opportunities within the corporation. Line management must also err on the optimistic side if it is to be more effective in the marketplace.

Our discussions with top management in these companies took a noticeably different tact. There was less evidence of long-term commitment. In some cases, there are plans to diminish the importance of this business to the corporation--because of the disenchantment and lack of belief that things were going to improve. We did find companies in which top management stated their long-term commitment and some of the reasons for it. More than one indicated they were in this business to stay--not for any expectations of greatly improved profitability in the short-term, but for the reasons of their belief in the growth and health of this business over the long haul.

APPENDIX TO

CHAPTER 1

Company____________

Date____________

DISCUSSION AGENDA
FOR ARTHUR D. LITTLE, INC. STUDY FOR EPA
OF THE POLLUTION CONTROL INDUSTRY

ISSUE CATEGORY SUMMARY

1. Regulatory Impacts upon the:
    - A) Operation and Performance of the Pollution Control Industry
    - B) Customer Purchase and Operation of Pollution Control Systems
    - C) Costs and Benefits of Pollution Control Compliance
2. Industry Capabilities for:
    - A) Meeting the Changing Bases of Demand
    - B) Developing Needed Technologies
    - C) Providing Sufficient Production Capacity
    - D) Achieving Attractive Financial Returns
    - E) Sustaining Sufficient Competition
3. Company-Specific Capabilities for:
    - A) Continued Investment in the Pollution Control Business

1. Regulatory Impacts upon the
A) OPERATION AND PERFORMANCE OF THE POLLUTION CONTROL INDUSTRY

Due to:

Demand pushes, delays, and bottlenecks

EPA's municipal funding policies
EPA's industrial incentive policies
EPA's R&D and demonstration policies

Different regulatory approaches
Foreign trade and technology policies
Energy and raw material policies

Expected effects of new legislation
EPA's interaction with the pollution control industry

1. Regulatory Impacts upon the
B) CUSTOMER PURCHASE AND OPERATION OF POLLUTION CONTROL SYSTEMS

What are the:

- Factors in the purchase decision
- Motivating forces and trends
- Trade-offs between capital and operating costs
- Differences among customer types
  - Large vs. small
  - Retrofit vs. "new source"
  - Public vs. private
- Relationships between suppliers and (reluctant) customers
- Turnkey or service needs of customers
- Current and future roles of "free engineering"
- Specific needs for more EPA information
- Changing EPA needs for operation, maintenance and monitoring informatio
- Criteria used by customers for pollution control equipment vs. process purchases
  - overdesign
  - durability
  - spares
  - standby
  - maintenance contracts and warranties

1. Regulatory Impacts upon the
   C) COSTS AND BENEFITS OF POLLUTION CONTROL COMPLIANCE

Uses of EPA reports on:
    Cost of Clean Air/Water
    Municipal Needs Survey
P.C. deflators or cost indices

Relative cost intensivity of:
    energy, labor, capital, raw materials, and marketing

Benefits from:
    P.C. Industry jobs
    Energy savings
    Product recovery
    Balance of payments

Costs/benefits of greater removal

2. Industry Capabilities for:
A) MEETING THE CHANGING BASES OF DEMAND

Definitions:

Product categories
Shipments vs. bookings
Non-EPA baseline

Markets:

Sizes and growth prospects
"Problem-industry" opportunities
Foreign business and forms thereof
Retrofit vs. "new source" vs. replacement
Equipment portion of total expenditures

Issues:

Relation to business cycle
Danger of demand peak/decline

Future Influence of:

Coal conversion programs
PSD and emission-offset policy
Pretreatment requirements
Toxic and hazardous regulations
In-process control approaches

2. Industry Capabilities for:
B) DEVELOPING NEEDED TECHNOLOGIES

Definitions:

Available technology
"Advanced" vs. "new and innovative"
Technology acceptance
Lead times for new developments
Roles of design firms

R&D capability of P.C. Industry
Areas of needed EPA R&D support

Future Influence of:

In-process or closed-loop systems
Greater automation and instrumentation
Energy conservation
Pollutant-specific regulations
BAT, LAER, etc., regulations
Cross-media impacts

SLUDGE??? and other residuals

2. Industry Capabilities for
C) PROVIDING SUFFICIENT PRODUCTION CAPACITY

Definitions:

Measures of relevant capacity
Boundaries of P.C. Industry
Stages of production/capacity

Capacity questions:

Overcapacity/utilization rates
Capacity to handle demand peaks
Flexibility of capacity

Bottlenecks in:

Raw materials
System components
Associated equipment
Fabrication capacity
Construction industry
Delivery times
Other lead times

2. Industry Capabilities for
D) ACHIEVING ATTRACTIVE FINANCIAL RETURNS

ADL preliminary analysis

Comments on it?
Best measures of return?
Bases for comparison?

General observations

Profitable? Trend?
Growth industry? Mature industry
A risky business?

Fixed price contracts; escalation clauses; phased payments.

Performance guarantees; warrantees; performance responsibility.

2. Industry Capabilities for
E) SUSTAINING SUFFICIENT COMPETITION

Competition/Concentration:

- Market shares and trends
- Leader identities and strengths
- Competitive comparisons
- Marketing differences

Product development:

- Product coverage/specialization
- Match with future needs

Competition/Entry:

- Consolidation trends
- Ease of entry
- Causes of entry failures
- Potential competition

Competitiveness:

- Trends and illustrations
- Foreign competition

3. Company-Specific Capabilities for:
A) CONTINUED INVESTMENT IN POLLUTION CONTROL BUSINESSES

Participation:

Overall sales volume
Involvement by segment
Growth outlook
Profitability vs. rest of company
Employee/sales ratios

Investment:

Available "capacity" and assets employed to P.C.
Effects of non-P.C. businesses
Capital availability
P.C. vs. investment criteria

R&D budgets, objectives, and needs for EPA sponsorship.

Attitudes toward this business (e.g., commitment, disappointment, etc.)

APPENDIX TO

CHAPTER 4

TABLE A4.1

ESTIMATED SPECIALTY EQUIPMENT BACKLOG[a] REQUIRED BY MUNICIPALITIES, BY SIZE OF PLANT

(millions of 1978 dollars)

	Size of Plant (MGD)					
Type of Treatment[b]	<0.30	0.30-1.5	1.5-2.9	2.9-14.8	>14.8	Total
Preliminary Treatment	11.6	1.9	0.4	0.6	0.2	14.7
Pumping	25.8	8.2	2.2	7.0	3.7	46.9
Preliminary Sedimentation	60.7	11.5	2.5	4.1	1.5	80.3
Trickling Filter	60.2	23.2	6.0	12.7	1.2	103.3
Activated Sludge	534.9	87.4	22.3	45.1	15.2	704.9
Filtration	99.3	28.2	9.8	20.0	5.5	162.8
Activated Carbon	43.3	4.0	2.4	3.5	0	53.2
Two-Stage Tertiary Lime	2.4	0.9	0.2	0.4	0.2	4.1
Biological Nitrification	19.0	10.1	3.3	6.2	2.2	40.8
Biological Denitrification	3.2	1.4	0.3	0.5	0.4	5.8
Ion Exchange	0	0	0	0	0	0
Breakpoint Chlorination	0.6	0.1	0.1	0.1	0	0.9
Ammonia Stripping	3.4	1.9	0.5	1.2	0	7.0
Disinfection	53.7	7.8	1.7	2.4	0.7	66.3
Anaerobic Digestion	128.2	26.8	5.8	10.6	4.2	175.6
Heat Treatment	1.3	1.4	1.1	2.8	0.8	7.4
Air Drying	11.0	5.5	2.0	6.8	1.7	27.0
Dewatering	97.8	40.9	29.7	58.1	30.2	256.7
Incineration	105.8	57.5	28.3	89.4	49.0	330.0
Recalcination	13.8	11.4	7.7	18.9	5.0	56.8
Totals	1276.0	330.1	126.3	290.4	121.7	2114.5

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[a] Required over the period 1977 through 1990.

[b] As defined by 1976 Needs Survey.

Source: Arthur D. Little, Inc., estimates based on EPA's 1976 Needs Survey.

TABLE A4.2

ESTIMATED SPECIALTY EQUIPMENT BACKLOG[a] REQUIRED BY MUNICIPALITIES, BY TYPE OF FACILITY

(millions of 1978 dollars)

Type of Treatment[b]	Plants Under Construction As of November 1976		Required by Existing Plants		Required by Future Plants Yet To be Funded	
	Enlarge And/or Upgrade	New Installations	Enlarge And/or Upgrade	New Installations	Enlarge And/or Upgrade	New Installations
Preliminary Treatment	0.2	0.5	5.6	0.1	-	9.0
Pumping	0.6	2.8	24.0	0.3	-	22.6
Preliminary Sedimentation	0.9	2.9	40.0	0.3	0.4	39.6
Trickling Filter	1.1	2.7	90.4	0	2.0	10.9
Activated Sludge	12.0	38.2	190.3	1.6	15.7	497.3
Filtration	5.9	10.7	10.8	1.0	10.5	140.5
Activated Carbon	1.6	2.5	0.4	0	2.1	50.7
Two-Stage Tertiary Lime	0.1	0.3	1.2	0	0.6	2.3
Biological Nitrification	0.9	3.2	1.5	0	4.7	34.6
Biological Denitrification	0.1	0.4	0.2	0	1.8	3.8
Ion Exchange	0	1.3	0	0	0	0
Breakpoint Chlorination	-	-	0.2	0	0.1	0.6
Ammonia Stripping	-	0.8	0.8	0	0.8	5.4
Disinfection	0.7	3.0	16.9	0.2	1.2	48.0
Anaerobic Digestion	2.6	5.6	85.3	0.3	2.0	88.0
Heat Treatment	0.8	1.4	4.3	0	0.8	2.3
Air Drying	0.4	1.4	17.9	-	0.2	8.9
Dewatering	5.5	13.3	133.6	2.0	11.0	110.1
Incineration	14.9	27.4	197.3	1.4	29.4	101.9
Recalcination	9.3	7.2	31.7	0	9.3	15.8
TOTALS	57.6	125.6	852.4	7.2	92.6	1,192.3

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[a] Required over the period 1977 through 1990.

[b] As defined by 1976 Needs Survey.

Source: Arthur D. Little, Inc., estimates based on EPA's 1976 Needs Survey.

TABLE A4.3

COMPARATIVE ESTIMATES OF INDUSTRIAL WASTEWATER TREATMENT BACKLOG, BY INDUSTRY, 1977 CAPACITY

Industry Sector	National Bureau of Economic Research		Environmental Protection Agency
	BPT	Pretreatment	BPT
	(millions of 1973 dollars)		(millions of 1975 dollars)
Asbestos	1	0	3
Bauxite	53	0	67
Beet Sugar	10	0	4
Builders Paper	9	0	7
Calcium Carbide	-	0	-
Cane Sugar	18	0	6
Cement	33	0	19
Coal Mining	3	0	0
Concrete Products	53	0	31
Dairies	45	0	275
Electrolytic Ferroalloys	2	0	No Estimate
Electroplating	431	1,232	149
Feedlots	42	0	40
Ferroalloys	13	0	10
Fertilizers	92	0	107
Fish Hatcheries	14	0	No Estimate
Fruits & Vegetables	29	0	45
Furniture	4	0	3
Glass	2	0	6
Grain	-	0	13
Insulation Fiberglass	13	0	10
Inorganic Chemicals	544	0	287
Iron Foundries	184	133	210
Iron and Steel	1,006	0	1,065
Laundries	5	257	No Estimate
Leather	40	26	46
Machinery and Mechanical Products	1,262	3,787	1,000

TABLE A4.3

COMPARATIVE ESTIMATES OF INDUSTRIAL WASTEWATER TREATMENT BACKLOG, BY INDUSTRY, 1977 CAPACITY (CONT.)

Industry Sector	National Bureau of Economic Research		Environmental Protection Agency
	BPT	Pretreatment	BPT
	(millions of 1973 dollars)		(millions of 1975 dollars)
Meat Processing	78	0	184
Mineral Mining	0	0	0
Miscellaneous Chemicals	875	99	No Estimate
Miscellaneous Foods and Beverages	199	0	No Estimate
Nonferrous	6	0	5
Ore Mining	69	0	60
Organic Chemicals	778	7	1,060 to 3,047
Paint and Ink	0	0	8
Paving and Roofing	4	0	4
Petroleum and Gas Extraction	60	0	68 to 149
Petroleum Refining	496	0	1,112
Phosphates	57	0	13
Plastics	295	1	328
Pottery and Clay	15	3	13
Poultry	18	0	18
Powerplants	2,310	0	1,080
Primary Aluminum	24	0	42
Printing	14	0	No Estimate
Pulp and Paper	1,704	0	1,716
Rendering	2	0	2
Rubber	72	0	75
Seafoods	33	0	26
Secondary Aluminum	3	0	2
Soaps and Detergents	6	38	14
Steam Supply	102	0	No Estimate
Textiles	69	43	80 to 100
Timber	75	0	50
Transportation	107	69	No Estimate
Water Supply	906	0	No Estimate
TOTAL	12,285	5,695	9,363 to 11,451

TABLE A4.4

LEADING INDUSTRIAL CATEGORIES IN VIOLATION OF THE JULY 1, 1977 (BPT) STATUTORY DEADLINE

Industry	Number of Facilities Reporting Under EPA's Permit Compliance System	Percent Number of Total Facilities in Noncompliance
Steel Works	95	46
Electric Power Plants	443	34
Pulp Mills	68	34
Primary Metals	187	21
Paper Mills	158	18
Plastic Materials	80	18
Petroleum Refining	150	17
Mining	81	17
Chemical Products	563	15
Textiles	192	15
Food Products	437	14
Stone and Concrete	104	14
Paper Products	179	10
Fabricated Metal Products	266	7

Source: EPA, as reported in June 1977.

TABLE A4.5

ESTIMATED ANNUAL EXPENDITURES FOR INDUSTRIAL WASTEWATER TREATMENT FACILITIES, 1974-1978

(millions of current dollars)

	1974	1975	1976	1977 Est.
WPC Capital Expenditures				
Primary Metals	140	200	300	300
Pulp and Paper	170	220	250	280
Chemicals	250	390	450	480
Petroleum Refining	300	440	480	500
Electric Utilities	420	380	660	640
All Other Industries	350	370	250	550
Total	1,630	2,000	2,400	2,750

Source: Arthur D. Little, Inc., estimates based on Bureau of the Census, Bureau of Economic Analysis, and industry surveys.

TABLE A4.6

ESTIMATED APC INVESTMENT REQUIRED TO MEET EXISTING FEDERAL STANDARDS, 1977-1986

(millions of 1978 dollars)

Industry	Total Requirements, 1970-1986			Investment Remaining 1977-1986		
	Existing Plants	New Plants	Total	Existing Plants	New Plants	Total
Energy Industries						
Fossil Fueled Power Plants	34,910	0	34,910	21,440	0	21,440
Commercial and Industrial Heating Boilers	NA	NA	NA	--	--	--
Total	34,910	0	34,910	21,440	0	21,440
Fuel Industries						
Natural Gas Processing	10	190	200	0	180	180
Petroleum Refining	0	3,730	3,730	0	3,240	3,240
Petroleum Storage	760	510	1,270	340	340	680
Petroleum Product	20	0	20	0	0	0
Marketing and Distribution Coal Cleaning	1,920	NA	1,920	NA	NA	NA
Lurgi Gasifiers	--	--	--	--	--	--
Total	2,710	4,430	7,140	340	3,760	4,100
Metal Industries						
Iron and Steel Industry	--	--	4,170	--	--	1,400
Iron Foundries Industry	--	--	600	--	--	220
Steel and Foundries Industry	--	--	320	--	--	20
Ferroalloys	380	0	380	0	0	0
Primary Lead	20	0	20	0	0	0
Primary Zinc	10,170	7,200	17,370	610	6,640	7,250
Secondary Aluminum	20	20	40	0	20	20
Secondary Brass	20	0	20	0	0	0
Secondary Lead	20	10	30	0	10	10
Secondary Zinc	10	30	40	0	30	30
Total	10,640	7,260	22,990	610	6,700	8,950

ESTIMATED APC INVESTMENT REQUIRED TO MEET EXISTING FEDERAL STANDARDS, 1977-1986 (Continued)

(millions of 1978 dollars)

Industry	Total Requirements, 1970-1986			Investment Remaining 1977-1986		
	Existing Plants	New Plants	Total	Existing Plants	New Plants	Total
Chemical Manufacturing Industries						
Petrochemicals	40	20	60	0	20	20
Vinyl Chloride	250	120	370	170	100	270
Nitric Acid	50	0	50	0	0	0
Sulfuric Acid	550	140	690	30	100	130
Phosphate Fertilizer	70	50	120	10	50	60
Nonphosphate Fertilizer	10	0	10	10	0	10
Mercury Cell Chlor-Alkali	40	0	40	0	0	0
Total	1,010	330	1,340	220	270	490
Quarrying and Construction Industry						
Cement	0	60	60	0	50	50
Structural Clay Product	120	10	130	10	10	20
Lime	120	0	120	10	0	10
Asphalt Concrete	300	100	400	10	60	70
Total	540	170	710	30	120	150
Other Manufacturing Services						
Paint Manufacturing	40	20	60	10	20	30
Surface Coating	NA	NA	NA	NA	NA	NA
Dry Cleaning	190	30	220	0	20	20
Total	230	50	280	10	40	50
Forest Products & Agriculture						
Kraft Paper	1,510	0	1,510	500	0	500
NSSC Paper	90	0	90	20	0	20
Feed Mills	2,030	60	2,090	120	0	120
Grain Handling	1,730	3,690	5,420	100	2,900	3,000
Total	5,360	3,750	9,110	740	2,900	3,640

ESTIMATED APC INVESTMENT REQUIRED TO MEET EXISTING FEDERAL STANDARDS, 1977-1986 (Continued)

(millions of 1978 dollars)

Industry	Total Requirements, 1970-1986			Investment Remaining 1977-1986		
	Existing Plants	New Plants	Total	Existing Plants	New Plants	Total
Solid Waste Disposal & Reduction						
Open Burning	2,770	2,720	5,490	230	2,720	2,950
Municipal Waste Reduction (Incinerators)	10	0	10	0	0	0
Refuse Fired Steam Generation	NA	NA	NA	NA	NA	NA
Sewage Sludge Incineration	340	0	340	110	0	110
Industrial & Building Incinerators	1,240	0	1,240	900	0	900
Total	4,360	2,720	7,080	1,240	2,720	3,960

Source: 1977 Cost of Clean Air, EPA

TABLE A4.7

SUMMARY OF ESTIMATED APC INVESTMENT REQUIRED TO MEET EXISTING FEDERAL STANDARDS, 1977-1986

(millions of 1978 dollars)

Industry	Total Requirements, 1970-1986			Investment Remaining, 1977-1986		
	Existing Plants	New Plants	Total	Existing Plants	New Plants	Total
Energy Industries	34,910	0	34,910	21,440	0	21,440
Fuel Industries	2,710	4,430	7,140	340	3,760	4,100
Metal Industries	10,640[a]	7,260[a]	22,990	610[a]	6,700[a]	8,950
Chemical Manufacturing Industries	1,010	330	1,340	220	270	490
Quarrying and Construction Industry	540	170	710	30	120	150
Other Manufacturing Services	230	50	280	10	40	50
Forest Products & Agriculture	5,360	3,750	9,110	740	2,900	3,640
Solid Waste Disposal & Reduction	4,360	2,720	7,080	1,240	2,720	3,960
TOTAL	59,760[a]	18,710[a]	83,560	24,630[a]	16,510[a]	42,780

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[a] Excludes breakdown of new and existing plants in the Iron and Steel and related industrial sector.

Source: 1977 Cost of Clean Air, EPA.

TABLE A4.8

CONTROL TECHNOLOGIES USED IN EPA-FUNDED ECONOMIC IMPACT STUDIES

ENERGY INDUSTRIES

Coal-fired Power Plants

- Particulate: Electrostatic Precipitators (Most Prevalent)
- Flue Gas Desulfurization: Venturi Scrubbers

Commercial and Industrial Heating Boilers

- SO_2: Dual Alkaline Scrubbers
- Particulate: Electrostatic Precipitators
- Flue Gas Desulfurization
- Hydrogen Sulfide: Amine scrubbing units

Fuel Industry

Natural Gas Processing Petroleum

- Hydrogen Sulfide: Claus Sulfur Plant Converting to Elemental Sulfur
- Particulate: High Efficiency Electrostatic Precipitators
- Carbon Monoxide: Boilers
- Hydrocarbons: Floating roof tanks petroleum storage

Coal Cleaning Industry

- Venturi Scrubbers

Lurgi Gasifiers

- Hydrogen Sulfide: Stetford and Claus Sulfur Recovery Plants
- SO: Tail-gas Scrubbers
- Nonmethane/Hydrocarbon Emissions: Incineration

CHEMICAL MANUFACTURING INDUSTRIES

Petrochemicals

- Thermal Incinerators (After Burners) Plus Heat Exchanger

Vinyl Chloride

- Fugitive Emissions Controlled Through Containment, Capture and Ducting
- Carbon Absorption Systems
- HCI: Incineration with Scrubbing

Nitric Acid

- Catalytic Reduction (Platinum or Palladium Catalyst)

CONTROL TECHNOLOGIES USED IN EPA-FUNDED ECONOMIC IMPACT STUDIES (CONTINUED)

Sulfuric Acid

- Dual Absorption System

Phosphate Fertilizer

- Particulate: Fabric Filters
- Particulate & Fluoride: Venturi Scrubber
- Waste Gases: Cyclone and Packed Scrubbers

Nonphosphate Fertilizers

- Liquid Ejector Venturi Scrubbers
- Liquid Impingement Systems
- Spray Towers

Chlor-Alkali Mercury Cell

- Brine Scrubbing
- Hypochlorite Scrubbing

METAL INDUSTRY

Iron and Steel Making Industry

Sintering Plants

- SO_2: High Energy Wet Scrubbers (Flooded Discs)
- Particulates: Fabric Filters, Cyclones, Electrostatic Precipitators

Coke Plants

- SO_2: Desulfurization
- Charging Car: Collector
- Particulate: Collection Hood

Open Hearth Furnace Steel Making

- Particulate: Electrostatic Precipitators
- SO_2: High Energy Scrubbers

Basic Oxygen Furnace Steel Making

- Particulate: Electrostatic Precipatators and Fabric Filters
- SO_2: High Energy Scrubbers

Electric

- Particulate: Baghouses
- SO_2: Wet Scrubbers

CONTROL TECHNOLOGIES USED IN EPA-FUNDED ECONOMIC IMPACT STUDIES (CONTINUED)

Iron Foundries

- Carbon Monoxide: Afterburners
- Particulates: Scrubbers and Fabric Filters

Steel Foundries

- Electric Arc Furnaces: Fabric Filters

Ferroalloys (Submerged Arc-Electric Furnaces)

- Particulates: Fabric Filters, Electrostatic Precipitators, High Energy Scrubbers

Primary Aluminum

- Particulate and Volatile Flourides: Hood and Ducting, Fluidized-bed Dry Scrubber, Wet Electrostatic Precipitators, Spray Towers

Primary Cooper

- SO_2: Cominco Absorption Process, Wet Lime Scrubbing, Wet Limestone Scrubbing

Primary Lead

- SO and Particulates: Sulfuric Acid Plants

Primary Zinc

- SO and Particulates: Sulfuric Acid Plants

Secondary Aluminum

- Dryer Emissions: Afterburners
- Sweating Furnace and Floride Emissions: Afterburners Followed by Wet Scrubber or Fabric Filters

Secondary Brass

- Particulates: Fabric Filters (67%), High Energy Scrubbers (28%), Electrostatic Precipitators (5%)

Secondary Lead

- Particulate: Fabric Filters or Wet Scrubbers

Secondary Zinc

- Zinc Oxide: Fabric Filters

CONTROL TECHNOLOGIES USED IN EPA-FUNDED ECONOMIC IMPACT STUDIES (CONTINUED)

QUARRYING AND CONSTRUCTION INDUSTRY

Cement

- Particulate: Fabric Filters for Blending, Grinding, and Drying
- Particulate: Fabric Filter and Electrostatic Precipitators for Kilns.

Structural Clay

- SO_2: Wet Scrubbers
- HC and CO: Afterburners

Lime

- Particulate: Cyclone Collector with Wet Scrubbers, Fabric Filters, or Electrostatic Precipitators

Asphalt

- Particulate: Cyclones, Fabric Filters, Settling Chambers
- SO_2: High Energy Wet Scrubbers

OTHER MANUFACTURING SERVICES

Points

- Gas: Flame Combustion, Catalytic Combustion, or Absorption, Thermal Combustion with Heat Exchange
- Particulate: Fabric Filters

Surface Coatings

- Exhaust Gas: Incineration, Flame Combustion, Thermal Combustion, Catalytic Combustion

Dry Cleaning

No technology given.

FOREST PRODUCTS AND AGRICULTURE

Kraft

No technology given.

NSSC

- SO_2: Sodium Based Double Alkali System SO_2
- Particulate: Electrostatic Precipitators

CONTROL TECHNOLOGIES USED IN EPA-FUNDED ECONOMIC IMPACT STUIDES (CONTINUED)

Grain Handling

- Dust Collection: Cyclones, Fabric Filters, Collector Hoods

Feed Mills

- Dust Collection: Cyclones and Fabric Filters

SOLID WASTE PROPOSAL & REDUCTION

Open Burning

No technology given

Municipal Waste Reduction

- Particulate: Electrostatic Precipitators
- SO_2: Wet Scrubbers

Refuse Fired Steam Generation

- Particulate: Electrostatic Precipitators

Sewage Incinerators

- Wet Scrubbers: Low Energy (50%), High Energy (50%)

Industrial and Commercial Building Incinerators

- Wet Scrubbers (80%)
- Afterburners (20%)

APPENDIX TO

CHAPTER 5

TABLE A5.1

AIR POLLUTION CONTROL EQUIPMENT MANUFACTURERS

APC Manufacturers for Which Pollution Control Businesses Are More Than 10% of Corporate Sales
(APC >10%)

Company	1976 Corporate Sales ($ MM)
American Air Filter	244
Buffalo-Forge	84
Carborundum	613
Combustion Equipment	128
Envirotech	416
Joy Manufacturing	630
Peabody International	327
Research-Cottrell	231
U. S. Filter	353
Wheelabrator-Frye	394
Zurn	242

Other* Companies for Which Pollution Control Businesses Are Less Than 10% of Corporate Sales
(APC <10%)

Company	1976 Corporate Sales ($ MM)
Babcock & Wilcox	4,270
Combustion Engineering	1,830
Dart Industries	1,476
Dresser Industries	2,232
Foster-Wheeler	1,061
GATX	830
Monsanto	4,270
U.O.P.	677

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*These companies were not included in analyses of representative financial returns for this industry group.

TABLE A5.2

AIR AND WATER POLLUTION CONTROL INSTRUMENTATION MANUFACTURERS

Company	1976 Corporate Sales ($ MM)
Beckman	242
Fischer & Porter	131
Foxboro	327
General Signal	616
Leeds & Northrup	143
Technicon	225

TABLE A5.3

WATER POLLUTION CONTROL EQUIPMENT MANUFACTURERS

WPC Manufacturers for Which Pollution Control Businesses Are More Than 10% of Corporate Sales

(WPC >10%)

Company	1976 Corporate Sales ($ MM)
Bird & Son	236
Carborundum	613
Culligan	82
Dorr-Oliver	148
Ecodyne	170
Envirotech	416
General Signal	616
Marley	230
Peabody International	327
Research-Cottrell	231
Rexnord	634
Zurn	242

Other* Companies for Which Pollution Control Businesses Are Less Than 10% of Corporate Sales

(WPC <10%)

Company	1976 Corporate Sales ($ MM)
Air Products and Chemicals	818
Airco	837
Combustion Engineering	1,830
Crane	1,087
Dart Industries	1,476
Dravo	812
Dresser Industries	2,232
Foster-Wheeler	1,061
FMC	2,144
Koppers	1,189
Pennwalt	777
Sterling Drug	638
Sunbeam	935
Sybron	576
Union Carbide	6,346
U.O.P.	677

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*These companies were not included in analyses of representative financial returns for this industry group.

TABLE A5.4

WATER TREATMENT CHEMICAL MANUFACTURERS

WT Chem Manufacturers for Which Pollution Control Businesses Are More Than 10% of Corporate Sales
(WT Chem >10%)

Company	1976 Corporate Sales ($ MM)
Betz Laboratories	142
Chemed	252
Mogul	66
Nalco	385
U. S. Filter	352

Other* Companies for Which Pollution Control Businesses Are Less Than 10% of Corporate Sales
(WT Chem <10%)

Company	1976 Corporate Sales ($ MM)
Allied Chemical Company	2,629
American Cyanamid	2,094
Dow Chemical	5,652
DuPont	8,361
FMC	2,144
Hercules	1,595
Merck	1,661
Monsanto	4,270
Olin	1,376
Rohm and Haas	1,053
Union Carbide	6,346
Westvaco	922

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*These companies were not included in analyses of representative financial returns for this industry group.

TABLE A5.5

SOLID WASTE MANAGEMENT COMPANIES

SWM Companies for Which Pollution Control Businesses Are More Than 10% of Corporate Sales (SWM >10%)

Company	1976 Corporate Sales ($ MM)
Browning-Ferris (>50%)	278
Carborundum	613
Combustion Equipment	128
Peabody International	327
Research-Cottrell	231
SCA Services (>50%)	165
Waste Management, Inc. (>50%)	179
Wheelabrator-Frye	394

Other* Companies for Which Pollution Control Businesses Are Less Than 10% of Corporate Sales (SWM <10%)

Company	1976 Corporate Sales ($ MM)
American Can	3,142
Combustion Engineering	1,830
Grumman	1,523
Raytheon	2,462
Union Carbide	6,346
U.O.P.	677

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*These companies were not included in analyses of representative financial returns for this industry group.

TABLE A5.6

INDUSTRY COMPOSITES FOR FINANCIAL COMPARISONS

Industrial Chemicals Composite

Allied Chemical
American Cyanamid
Celanese
Diamond Shamrock
Dow Chemical
DuPont
Ethyl Corporation
W. R. Grace
Great Lakes Chemical
Hercules
Kewanee Industries, Inc.
Koppers
Monsanto
Olin
Pennwalt
Rohm and Haas
Union Carbide

Industrial Machinery Composite

A.T.O., Inc.
Amtel, Inc.
Briggs and Stratton
Chicago Pneumatic Tool
Cooper Industries, Inc.
Gardner Denver Company
Ransburg Corporation
Hobart Corporation
Ingersoll Rand
Mesta Machine Co.
Milton Roy Co.
National Mine Service Co.
New Hampshire Ball
Hannifin

Instrumentation Manufacturing Composite

American Precision
Badger Meter
Daniel Industrials, Inc.
Esterline Corporation
Fischer & Porter
Gerber Scientific Instruments
General Signal
Instron Corporation
LFE Corporation
Lynch Corporation
Simmond Precision Products

APPENDIX TO

CHAPTER 7

TABLE A7.1

L=Volume Leader
X=Significant Participation

	APC Equipment	Instrumentation	WPC Equipment	Chemicals	Resource Recovery
Air Products and Chemicals			X		
Allied Chemical				X	
Allis-Chalmers					X
American Air Filter	L				
American Can (Americology)					X
American Cyanamid				X	
Apollo Chemical				X	
Autotrol			X		
Babcock & Wilcox (McDermott)	X				
Beckman Instruments		L			
Bendix		X			
Betz Laboratories			L		
Bird & Son			X		
Black Clawson					L
Boeing					X
Browning-Ferris					X
Buffalo Forge	X				
Carborundum (Kennecott)	X		X		X
Carter, Ralph B.			X		
Chemed (W. R. Grace/Dearborn)				L	
Chicago Bridge & Iron (Walker)			X		
Clow			X		
Combustion Engineering	L		X		X
Combustion Equipment Assoc.	L	X			L
Dart Industries	X		X		
Davis Water & Waste			X		
Davy Powergas	X				

TABLE A7.1 (cont.)

	APC Equipment	Instrumentation	WPC Equipment	Chemicals	Resource Recovery
Dorr-Oliver (Curtiss-Wright)			L		
Dow Chemical			X	X	
Dresser Industries	X		X		
DuPont		X	X	X	
Ecodyne (Trans Union)		X	L	X	
Envirotech	L	X	L		X
FMC	X		L	X	
Fischer & Porter		L			
Fisher-Klosterman	X				
Foster-Wheeler	X		X		
Foxboro		L			
General Signal	X	L	X	X	
Goodrich, B. F.			X		
Grumman					X
Hercules				X	
ICI United States				X	
Infilco			X		
Ionics		X	X		
Joy Manufacturing	L		X		
Koch Industries	X		X		
Komline-Sanderson			X		
Koppers (Environmental Elements)	X		X		
Lear Siegler		X			
Leeds & Northrup		X			
Marley			X		
Merck (Calgon)			X	L	
Mogul (Dexter)				L	
Monsanto	X		X		X

TABLE A7.1 (concl.)

	APC Equipment	Instrumentation	WPC Equipment	Chemicals	Resource Recovery
Nalco				L	
Neptune International	X	X	L		
Occidental Petroleum			X		X
Olin				X	
Parkson			X		
Passavant			X		
Peabody International	X		X		
Pennwalt			X		
Raytheon					X
Research-Cottrell	L		X		X
Rexnord (Envirex)	X		L		
Rohm and Haas				X	
Shirco			X		
Sterling Drug (Zimpro)			X		
Sunbeam	X		X		
Sybron		X	X	X	
Technicon		X			
Teledyne					X
UOP (Signal)	X		X		X
U. S. Filter	L	X	X	L	
Union Carbide	X		X	X	
Waste Management, Inc.					L
Westvaco				X	
Wheelabrator-Frye	L		X		L
Zurn Industries	X		X		